PUBLIC ROADS

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UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC ROADS

VOL. 9, NO. 2 APRIL, 1928

ROADSIDE TREATMENT ON A MASSACHUSETTS STATE HIGHWAY

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Owing to the necessarily limited edition of this publication it will be impossible to distribute it free to any persons or institutions other than State and county officials actually engaged in planning or constructing public highways, instructors in highway engineering, periodicals upon an exchange basis, and Members of both Houses of Congress. At the present time names can be added to the free list only as vacancies occur. Others desiring to obtain "Public Roads" can do so by sending 10 cents for a single number or $1 per year to the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

HOW MASSACHUSETTS IS IMPROVING HER ROADSIDES

Reported by R. E. TRIBOU, Assistant Highway Engineer, District 9, United States Bureau of Public Roads

THE WORK of roadside treatment which Massachusetts started in 1921 has within a relatively few years produced a marked effect on the beauty of its highways, which will be even more striking in future years. Massachusetts is one of the few States where organized attention is given to roadside beautification and because of the general interest in the subject it appears to be worth while to present a short description of the general plan of beautification and methods of handling the work which have produced good results on a considerable mileage of road at a very reasonable cost.

A BORDER PLANTING

The Massachusetts Department of Public Works is empowered by law to make roadside improvements, the work including such plantings, replacements, and care as may be necessary. When a road is laid out as a State highway, it is generally made sufficiently wide to provide an area on each side of the traveled portion for roadside improvement. No tree, shrub, or plant within such a highway can be cut, removed, or new ones added without a permit from the highway department.

The work of roadside improvement is done by the maintenance division of the department of public works which is in charge of G. H. Delano, highway engineer. The cost is included as a part of the regular maintenance expenditure of the State. The State has a nursery at Palmer, Mass., where trees and shrubs are propagated and where J. H. Taylor, highway landscape supervisor, trains men in the care of trees and roadside beautification. This nursery is a part of the maintenance division. The following outline shows the scope of the work being done.

ATTENTION TO NATIVE MATERIAL

Removal of dead material.—Dead and dangerous branches are systematically removed. Trees entirely dead are removed and stumps cut 6 inches below the ground surface.

First aid to injured trees.—Mechanical wounds to trunk or branches are trimmed and sealed with tar. Trees split or in danger of splitting are fastened with bolts or cables. Open cavities are suitably repaired.

Care of trees.—Unsightly, abnormal, or rubbing branches are removed. Pruning and shaping is done by trained men. Spraying is done when necessary. Preservation and culture of natural growth is important work. Intelligent care of this sort will add much to the future beauty of roadsides.

Safety work.—Standard traffic clearance is maintained.

Landscape cutting.—Vistas of mountains, lakes, and streams are developed by removal of foliage screens.

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An Invitation to Be Neat

A Bare Sand Bank Relieved by Planting Sweet Fern

Ready for a Pine Planting Trip

Wire clearance work.—The State supervises all tree trimming for passage of public service wires and prohibits careless and unnecessary cutting.

Public enjoyment and education.—Roadside springs are made available to travelers. Benches are provided in suitable places. Public cleanliness is invited by placing rubbish barrels.

INTRODUCTION OF NEW MATERIAL

Healing construction scars.—Gravel and sand slopes are planted with small pines or other adaptable ground cover. Grass or shrubs are planted where the soil will support growth.

Tree and shrub planting.—Trees, shrubs, and vines adapted to soil conditions are planted on roadsides, traffic islands, behind guard rails or stones, etc.

Replacements.—Historical and normal growth is perpetuated by annual replacement of the dead with the living.

Maintenance.—The success of all planting depends solely upon maintenance. Young trees and shrubs must have care. The future beauty of trees depends largely upon their training in youth, which means that trees should be staked and pruned annually and intelligently. Shrubs must be cut back properly to insure a graceful maturity and soil about the base of all planted stock kept open for proper moisture and air. Such work is imperative and must be done regularly.

The men engaged in this work are advised to study how nature plants and imitate it as far as possible. The object is to keep the roadsides as natural as possible by the use of native material. A Colorado blue spruce on a Massachusetts roadside is distinctly out of place and artificial since it is not characteristic of Massachusetts. Importations may be attractive but they do not reflect the personality of the State.

Plantings on roadsides are mainly confined to new construction for several reasons. The wider locations (60 feet or more) give more opportunity for scenic development, and these relocated and widened roads promise a fairly undisturbed future. Shade trees are planted as near as possible to the side line, but for the most part the monotony of straight lines and even spacing is avoided. Grouping of trees and shrubs is at all times preferable.

Planting procedure.—After a construction job is completed the plan of treatment is determined by an employee trained in the work, who locates the various plantings on a blue print of the layout, using colored pencils. Next the ground is staked for digging. Digging costs are decreased 50 per cent and an extended area is stirred up when holes are blown by dynamite. Pits are filled with the best soil obtainable.

An order for the necessary planting material is forwarded to the nursery and the material is delivered by trucks and trailers. Plantings are carefully made, giving the trees or shrubs every opportunity to get a good start and each planting is staked. After the planting has become well established a final grubbing is given.

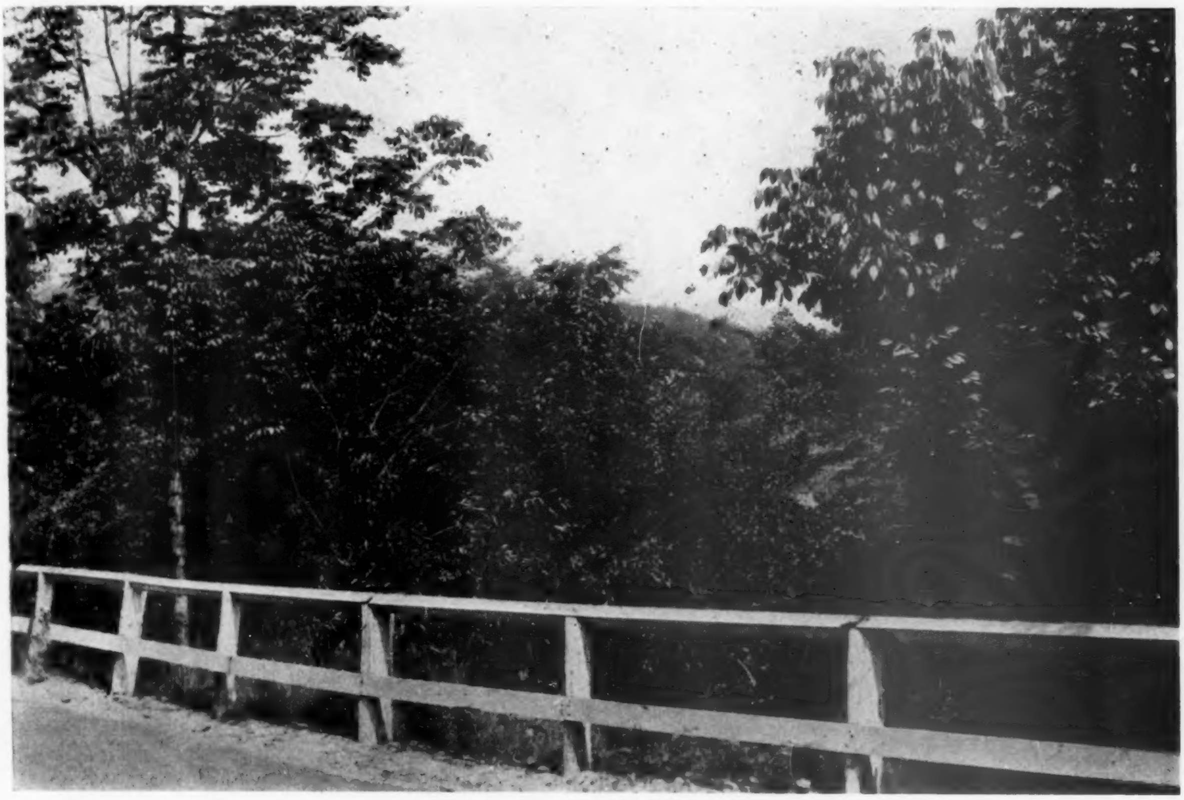
The results which are being secured are best described by the accompanying illustrations which were taken by Mr. J. H. Taylor, Highway Landscape Supervisor.

An Old, Rotten, and Unsightly Growth of Stumps

Stumps Removed, Allowing Rapid Development of the Secondary Growth

Before Landscape Cutting

The Result of Landscape Cutting at the Location Shown Above



A Dense Undergrowth Which Cuts Off a Beautiful Vista

After Landscape Cutting at the Location Shown Above

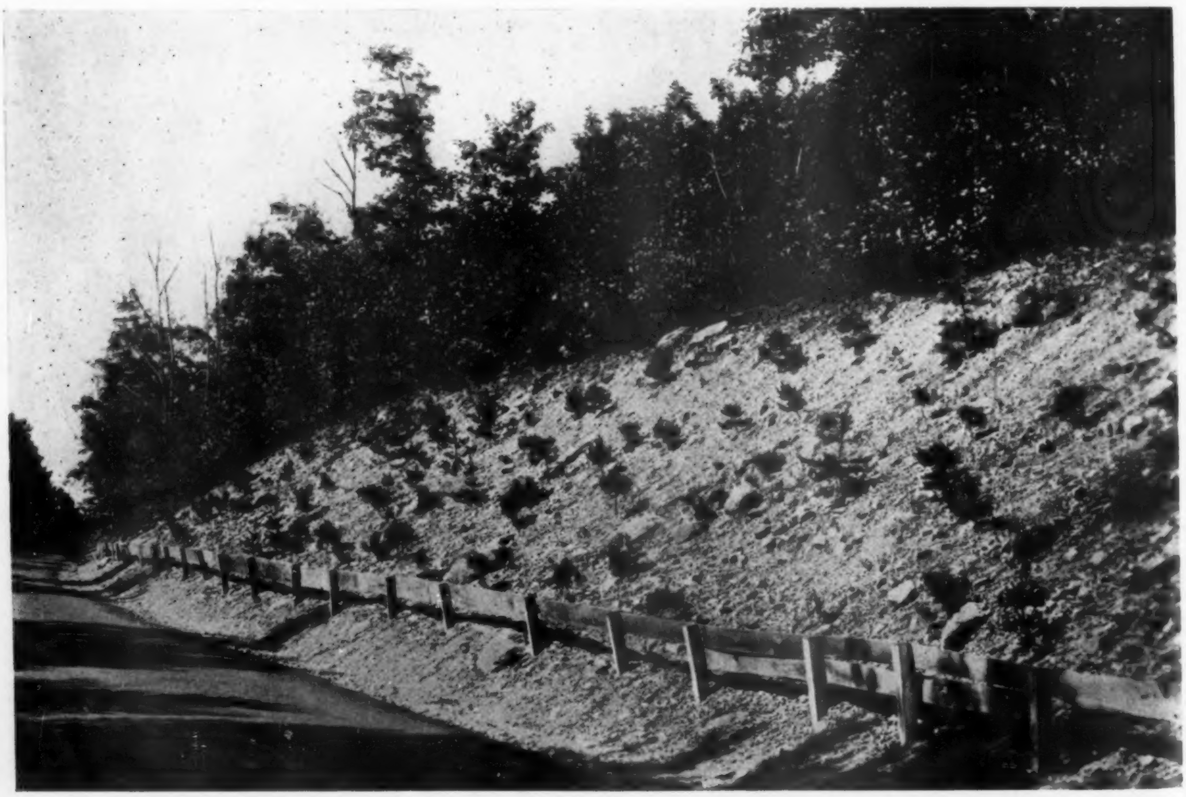
DEVELOPING A GROUP OF BIRCHES

GREY BIRCH, WITH BRUSH AND LOWER LIMBS REMOVED FOR TRUNK EMPHASIS

A Wayside Spring Developed

Tree Surgery Can Greatly Improve Trees of Undesirable Shape. As a Result of 20 Minutes' Work on the Tree Shown at the Left It Has Been Converted into a Tree of Much Better Proportions

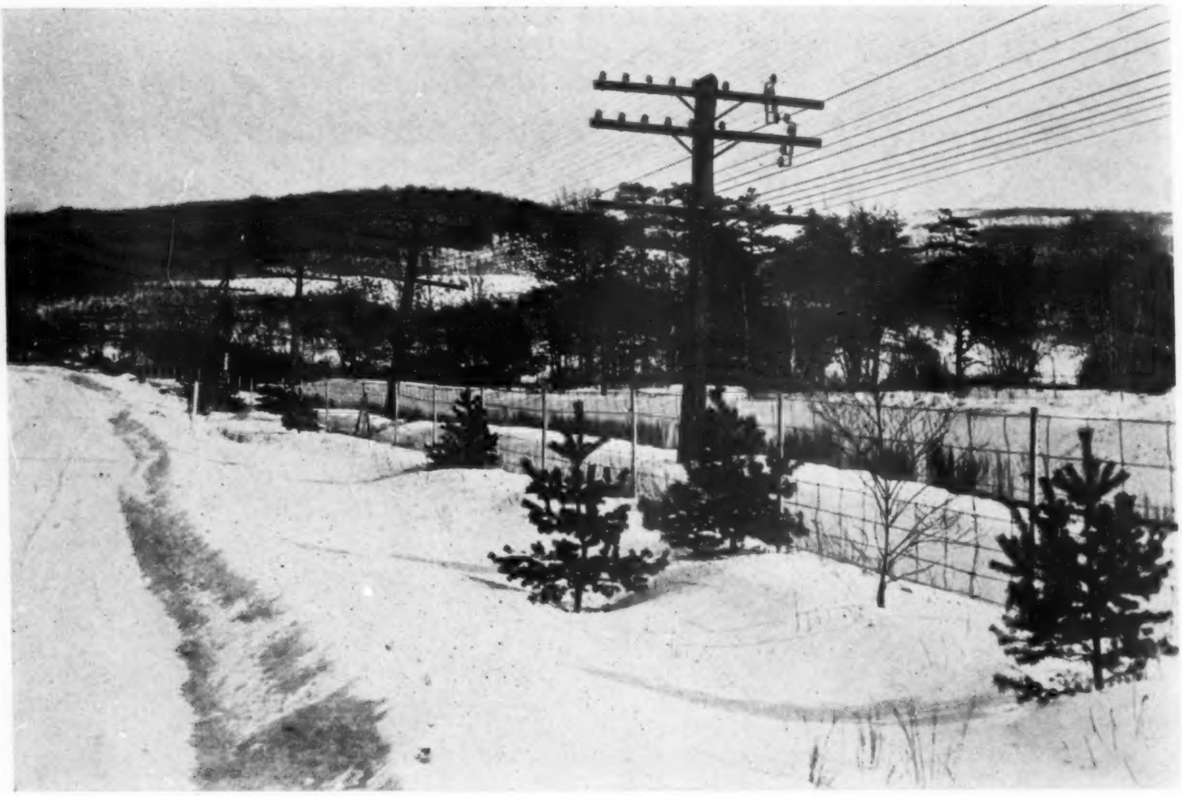
Clover on Chipped Stone and Gravel Bank 41 Days After Sowing Seed



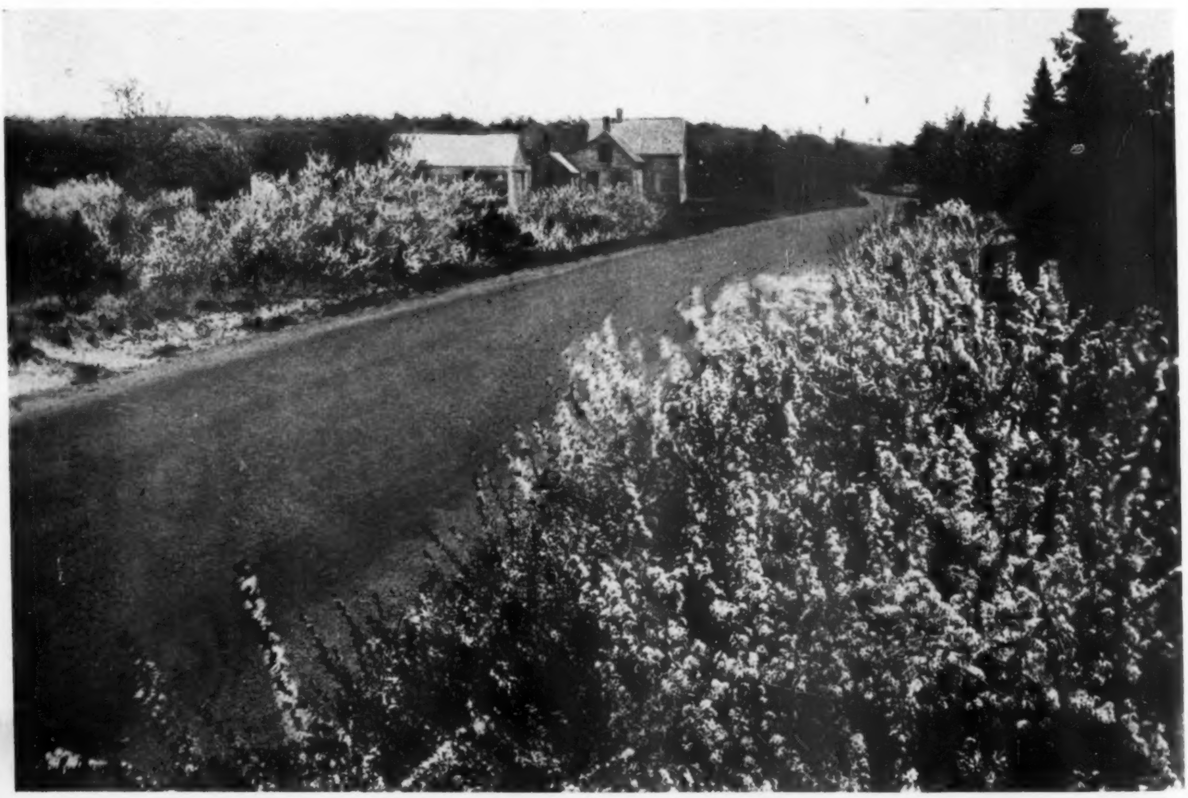
Pine Planting in Untreated Bank

The Elderberry is Worth Saving

Softening the Harsh Lines of Protective Stones

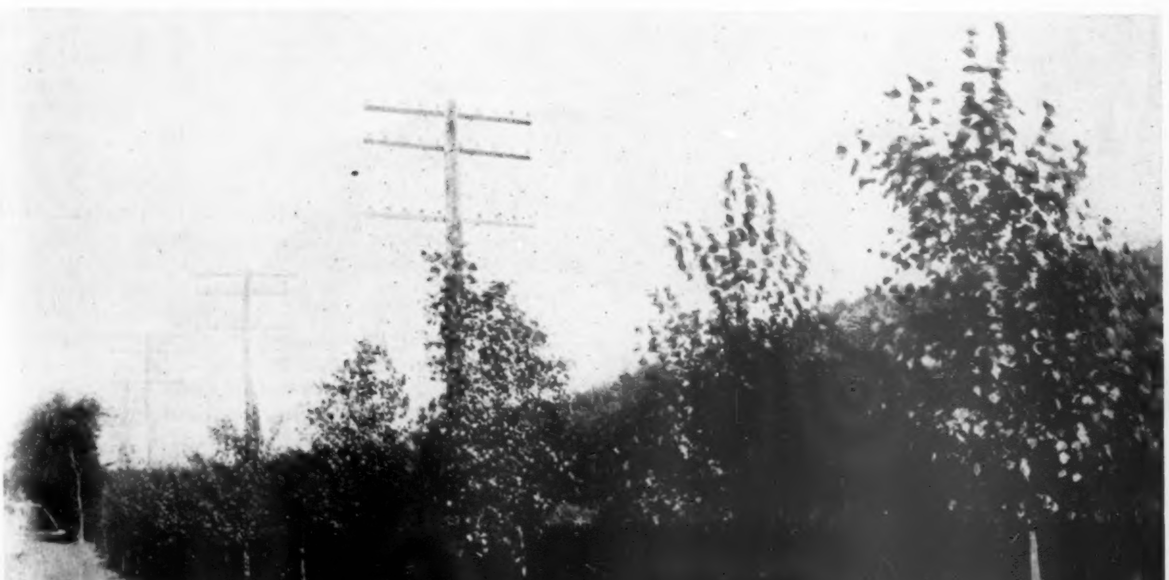


Here and There Evergreen Plantings Liven the Winter Landscape



A Beach Plum Border on Cape Cod

The Glory of Common Things



Landscape Greatly Improved by a Tree Planting Along a Board Fence

An Unsightly Gravel Bank Which Has Been Covered with Honeysuckle

An Example of What Can Be Done by Removal of Telephone Poles and Wires. The Wires Shown in the Upper Picture are Carried in a Cable Shown at the Left in the Lower Picture

R. W. CRUM APPOINTED DIRECTOR OF HIGHWAY RESEARCH BOARD

Announcement is made by F. H. Eno, chairman of the executive committee of the highway research board of the National Research Council, of the appointment of Roy W. Crum, of Ames, Iowa, as director of the board, effective April 1, 1928.

Mr. Crum's experience in research work well qualifies him for this position. After graduation from the Iowa State College in 1907 he was engaged on the engineer corps of the Pennsylvania Lines, following which he returned to Iowa State College as associate professor of civil engineering. He remained in this position for 12 years, during which time he was engaged on research work for the Iowa experiment station. Since 1919 he has been engineer of materials and tests with the Iowa State Highway Commission where he has conducted many highway research studies. Mr. Crum has been a member of the committee on character and use of road materials since the organization of the board, and in 1925 he was appointed chairman of the culvert investigation conducted by the highway research board.

Mr. Crum is the author of a number of important research papers. He is a member of the American Society of Civil Engineers, the American Society for Testing Materials, and the American Concrete Institute and is active on several research committees of those organizations.

POWER-SHOVEL OPERATION IN HIGHWAY GRADING

A REPORT OF OBSERVATIONS MADE ON GOING PROJECTS BY THE DIVISION OF MANAGEMENT, BUREAU OF PUBLIC ROADS

Reported by T. WARREN ALLEN, Chief, Division of Management, and ANDREW P. ANDERSON, Associate Highway Engineer

PART 3.—HAULING WITH TRUCKS AND LARGE TRACTOR-DRAWN WAGONS

TRUCKS of various kinds are frequently used to transport the output of power shovels on highway work. The bureau's studies indicate that opinion is far from uniform as to the most desirable type of truck or on such points as tire equipment, carrying capacity, dumping arrangement, and body types. Practically all of the common types of trucks now in use for general hauling have been found on grading projects and in capacities ranging from the light 1-ton to the heavy 7-ton truck.

With such diversity of types, it is only natural that wide variations should also be found in the efficiency with which they meet the specialized requirements of highway grading. Moving material from the shovel to the dump is quite different from highway transportation and there is little or no dependable data to guide the grading contractor in selecting trucks for hauling. Both successes and failures have been found during these studies. It appears worth while to discuss in some detail the requirements and conditions under which the truck may be used to good advantage and also the conditions which sometimes make their use inadvisable.

The truck is a well-built, dependable machine, but moving material from the shovel to the dump sometimes offers so many adverse conditions such as soft ground, rough going, and difficult grades that there is probably no field in which operating conditions are more variable and severe. Wear and tear on vehicles is often excessive, the speed much reduced and operating costs abnormally high when compared with production. This is a condition which should not be attributed to shortcomings of the truck as a hauling unit but is due very largely to poor judgment in selecting trucks for jobs to which they are not suited, to selection of the wrong kind of trucks or to lack of ability in their management on the job.

TIME CONSTANT FOR TRUCKS STUDIED

The operation characteristics of the truck differ considerably from those of the team and wagon. The first and perhaps the greatest difference is in the time constant, that is, the time required to take on the load, to dump it, and to perform all turning and maneuvering, together with such waits and delays as may be necessary on each round trip. For a two-horse team and wagon the time constant may be as low as one minute and should never exceed two minutes in good common excavation. Tables 1 to 3 show the results of time constant studies on typical jobs using different makes and sizes of trucks, and Table 4 shows the average value of the time constant on each of these jobs.

The loading time is, of course, entirely dependent on the capacity of the hauling vehicle and the rate of shovel output. So long as trucks can be exchanged during the shovel cycle this item need not be given consideration in the selection or control of the hauling equipment. The time required to dump a heavy load is often comparatively large, especially if the material is very sticky. The lightest trucks used in this work are generally equipped with gravity-dump bodies. Practically all others are equipped with a mechanism for raising the front end of the truck body to an angle at which the material is supposed to slide out through the unlatched rear gate. Both the rate at which the hoisting mechanism operates and the angle to which it will tilt the body vary considerably with different makes. During two of the one-hour studies on job No. 44 (Table 1) the average dumping time exceeded two minutes due to adhesive material or large chunks wedging in the body. Tables 1 to 4 show, however, that the dumping time for trucks in good condition and under average operating conditions may be expected to vary between 15 and 25 seconds for light, 1-ton trucks, between 30 and 45 seconds for medium trucks, and from 50 to 80 seconds for heavy trucks.

ROADWAY IN GOOD CONDITION AND TRUCK SPOTTED FOR LOADING AT THE SIDE

TIME LOSSES DUE TO TURNING AND BACKING GENERALLY AN IMPORTANT ITEM

Trucks must generally be turned around twice with each load carried except on some short haul work. This takes time because under most ordinary conditions some backing is required. The roadway width varies a good deal in different States. A width of about 30 feet is perhaps the most common but it is not unusual to have a width of several feet more or several feet less. Thirty feet of width is sufficient for quick turning if it can all be used, but usually a strip some 5 feet along the edge of the dump is so soft that it will hardly carry the weight of an empty truck. The usable area is often so restricted that the truck has to pull forward and back a number of times before it can complete the turn. In a through cut the condition is not apt to be so bad but even here it is seldom possible to make the turn without some backing. The time used in turning, as obtained on several jobs, is shown in Tables 1 to 4. For the heavier vehicles the total time required for turning and spotting to receive and dump the load during each round trip is rarely less than 75 seconds and may under adverse conditions exceed 3 minutes. Where the operating space is

Table 1.—*Time constant studies on two jobs using 3½-ton trucks (make A[1]) and ¾-yard power shovels; each entry is the average of a one-hour study*

JOB NO. 41

[Time constant, 272.1 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
5.0	173.5	2.5	24.5	39.2	23.0
5.0	127.4	23.2	30.2	56.4	25.4
4.8	158.2	17.0	22.7	28.8	20.3
6.0	151.7	....	18.5	25.5	27.2
5.8	182.2	....	22.2	29.2	20.2
6.0	189.0	68.0	22.0	29.3	24.5
6.0	190.0	17.7	24.0	31.7	24.1
6.1	164.4	8.4	25.4	25.4	21.6
6.1	152.0	26.5	23.7	29.0	19.8
6.0	213.7	4.2	26.3	37.3	23.8
6.0	179.7	....	25.7	28.7	24.6
6.0	250.0	....	21.4	35.2	29.2
Av. 5.7	177.6	14.0	23.9	33.0	23.6

JOB NO. 44

[Time constant, 290.8 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
3.0	78.3	....	15.3	26.3	33.0
3.4	82.4	428.6	15.0	132.0	40.0
3.0	67.5	329.0	15.0	63.0	48.5
3.3	92.3	378.3	16.0	122.0	47.6
3.2	72.5	6.2	15.0	53.5	15.0
3.8	91.2	79.5	14.7	31.7	62.2
4.0	92.0	....	13.5	20.5	53.5
4.0	79.0	16.2	12.6	22.6	59.4
4.0	74.2	3.8	10.4	22.6	25.0
4.0	66.8	....	11.4	21.0	42.8
4.0	80.0	45.6	14.2	23.2	28.0
4.0	101.0	17.4	14.6	19.8	27.8
Av. 3.6	81.4	108.7	14.0	46.5	40.2

[1] In this discussion letters have been substituted for the names of truck manufacturers.

Table 2.—*Time constant studies on two jobs using different sizes and makes of trucks; each entry represents a single observation*

3½-TON TRUCKS (MAKE B), LOADED BY A 1-YARD POWER SHOVEL

[Time constant, 274.4 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
5	149	....	27	25	44
5	130	....	35	16	50
5	142	....	16	17	35
6	209	....	53	57	102
6	236	....	23	57	40
6	213	....	10	17	26
5	161	....	21	24	29
5	170	....	58	40	36
6	180	....	30	48	32
5	151	....	17	24	44
5	146	....	24	21	23
5	138	....	17	15	49
5	150	....	40	39	45
5	170	....	26	19	32
5	175	....	26	33	56
5	135	....	42	30	58
5	165	....	20	15	35
6	200	....	16	30	30
6	264	....	41	36	39
5	175	....	38	20	62
Av. 5.3	172.9	....	29.0	29.2	43.3

Table 2.—*Time constant studies on two jobs using different sizes and makes of trucks; each entry represents a single observation*—Con.

1-TON TRUCKS (MAKE C), LOADED BY A ¾-YARD POWER SHOVEL

[Time constant 114.3 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
1	16	....	24	10	37
2	60	....	40	55	15
1	16	....	32	7	56
1	26	....	17	83	32
1	6	48	28	13	36
1	18	78	10	12	24
2	27	....	28	31	20
2	31	11	39	26	18
2	37	....	24	26	21
2	46	....	36	17	20
2	47	....	28	24	20
2	28	....	24	41	21
2	31	....	25	12	24
2	42	[1] 166	23	10	19
2	44	....	17	15	21
2	37	....	22	19	19
2	29	....	11	13	22
2	34	....	19	23	17
2	37	....	28	14	13
2	54	....	45	40	16
Av. 1.75	33.3	6.9	26.0	24.5	23.6

[1] Not included in average.

Table 3.—*Time constant study on a job using 5-ton trucks (make D), hauling over an old road surface in good condition, each entry represents the average of a days study*

[Time constant, 536 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
5.0	140	232	57	122	138
7.7	339	14	37	110	98
7.0	261	45	68	88	96
9.3	387	120	89	59	62
7.5	400	298	63	43	64
6.0	222	39	61	68	80
6.7	214	10	95	84	92
5.7	250	37	62	65	58
6.3	250	98	93	64	47
6.7	234	49	118	57	51
4.8	173	17	88	46	53
5.0	187	47	54	65	60
5.3	185	61	44	135	49
5.7	252	7	60	43	46
6.3	257	46	37	53	55
4.3	160	239	76	41	45
4.7	166	187	57	50	45
Av. 6.6	240	91	68	70	67

Table 4.—*Average value of time constant with various types of trucks; each entry is average found for a job study*

Kind of equipment	Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel	Total time constant
	Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
3½-ton, make A	5.7	177.6	14.0	23.9	33.0	23.6	272.1
3½-ton, make A	3.6	81.4	108.7	14.0	46.5	40.2	290.8
3½-ton, make B	5.3	172.9	....	29.0	29.2	43.3	274.4
5-ton, make D	6.6	240.0	91.0	68.0	70.0	67.0	536.0
1-ton, make C	1.75	33.3	6.9	26.0	24.5	23.6	114.3

restricted trucks with a short wheel base have a definite advantage, and save much time.

With rear-wheel drive it is often impossible to take full advatange of the minimum radius on which a truck will turn and this is especially true where ground conditions are bad and the vehicle will stall if the front wheels are cut the maximum amount. For this reason it is not to be expected that a truck will turn on as short a radius under the conditions commonly prevailing on a construction job as it will turn on an improved highway.

Backing frequently increases the time constant. The backing speed of most trucks is relatively low. In spite of this handicap trucks are quite often backed a much greater distance than is necessary in getting into position at the shovel and are often backed into position at the dump. Some backing may be desirable and it has been pointed out that sufficient attention is seldom given to spotting the trucks at the shovel

TABLE 5.—*Hauling speed and time constant on a job where 5-ton trucks (make D) with solid tires were used; each entry is the average of one day's study*

[The trucks were backed to the dump down a 11 per cent grade with a good surface. Average time constant 208 seconds]

Time constant				Round-trip speed				
Dippers per load	Loading	Waiting at dump	Dumping	Haul	Time		Average speed	
					Haul in reverse	Return forward	Haul in reverse	Return forward
Number	*Seconds*	*Seconds*	*Seconds*	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
3.2	106	60	111	340	146	84	139	243
3.2	77	....	51	360	140	89	154	243
4.0	102	9	93	400	163	83	146	289
3.3	90	55	79	420	177	89	142	283
Av. 3.4	94	31	83	380	156	86	145	264

TABLE 6.—*Hauling speed on a job where 3½-ton trucks (make A) with solid tires were used; each entry the result of a single observation*

The trucks were backed to the dump down a grade varying from 4 to 10 per cent and from fair to poor condition]

Dippers per load	Haul	Time		Average speed	
		Haul in reverse	Return forward	Haul in reverse	Return
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
5	630	260	205	145	184
5	630	232	149	163	253
5	630	209	150	181	252
5	630	203	113	186	334
5	530	165	100	192	318
5	530	210	150	151	211
5	530	155	130	205	244
5	530	210	160	151	198
5	475	179	84	159	340
5	475	140	113	204	252
5	475	171	107	167	267
5	475	158	83	180	344
5	475	130	101	219	282
5	740	235	152	189	292
5	740	222	178	200	249
5	740	250	167	178	265
5	740	265	155	168	286
5	800	275	171	175	281
5	800	293	178	164	270
5	800	272	157	177	311
Total or av ...	12,375	4,234	2,803	175	265

TABLE 7.—*Hauling speed of 3½-ton trucks (make B) equipped with dual pneumatic tires on the rear wheels*

[Loaded trucks moved down grade over a fairly smooth surface]

Dippers per load	Haul	Time		Average speed	
		Haul	Return	Haul	Return
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
6	1,850	149	117	748	950
5	1,850	135	150	821	742
6	1,850	155	125	718	890
4	1,850	105	112	1,051	993
4	1,850	97	122	1,145	910
6	1,850	137	135	811	821
5	1,850	120	114	927	975
5	1,400	113	115	743	730
4	1,400	87	104	965	808
4	1,400	80	134	1,050	626
5	1,400	80	97	1,050	867
5	1,400	105	141	800	595
4	1,400	79	122	1,064	688
5	1,400	103	140	816	600
5	1,400	95	123	886	656
Total or av. 73	24,150	1,640	1,856	883	781

NOTE.—At one time the trucks were required to turn and back to shovel, a distance of 475 feet. The average speed in reverse was 400 feet per minute. Operation in this manner not included in above table.

TYPICAL OPERATION WITH LIGHT TRUCKS ON PNEUMATIC TIRES. THE LOWER PICTURE ILLUSTRATES A CASE WHERE SHUTTLING CAN BE PRACTICED TO ADVANTAGE

so as to take advantage of the greater production which is possible when loading at the side instead of behind the shovel.

BACKING LOADED TRUCKS TO DUMP SOMETIMES ADVANTAGEOUS

On short-haul work—hauls up to 400, 500, or 600 feet—much time can often be saved by shuttling trucks—that is, backing them under load to the dump and driving them forward to the shovel. A skillful truck driver will soon learn to back a truck to the dump almost as easily and accurately as he can drive it forward. The distance over which it pays to shuttle trucks depends on whether the time lost due to slow speed in backing is compensated for by the saving in turning time. In theory there is a wide difference be-

tween normal driving speed ahead and in reverse. In practice the observed backing speed is usually relatively high when compared with the forward hauling speed as indicated by Tables 5, 6, and 7. Where this is true and the turning time is large, the distance over which shuttling can be done to advantage is considerable.

Shuttling is not resorted to as often as it ought to be nor to as great a distance. Under the conditions given in Tables 5, 6, and 7, shuttling could have been practiced up to a distance of about 700 feet in each case. On short hauls—that is, on hauls up to 200 or 300 feet—shuttling the trucks sometimes nearly doubles their output. It also improves operating conditions, as where trucks are turning both at the dump and at the shovel it is hard to manage the trucks so that they will not interfere with each other.

Road Conditions Have an Important Bearing on the Efficiency of Truck Hauling, Particularly with the Larger Sizes of Trucks

PNEUMATIC TIRES BETTER THAN SOLID TIRES FOR OPERATION ON SOFT GROUND

Heavy trucks are apt to mire down in soft ground and they are not well adapted to the conditions prevailing when layer dumping is required unless the material compacts easily. End dumping is much better suited to truck hauling. Even then, for fast truck operation the load must be dumped some little distance from the edge and then pushed over with a bulldozer. The increased confidence with which the trucks can be handled when they are not required to drive close to the end of the fill, to say nothing of the accidents which occur on such work, generally reduce the average time per load enough to more than pay the extra cost of the bulldozer.

Soft ground on the dump and around the shovel causes many delays. In a deep cut the moisture content of the soil at the bottom of the cut is apt to be high. Clay is often in a plastic condition, a good deal like stiff putty and yields readily under heavy loads. In the fill the same condition is retained and is made worse by every rain. Trucks may be mired down, causing a loss of time not only for the mired truck but also for those sent to its assistance. Much of this difficulty is due to the use of trucks where a careful examination would have indicated that other hauling

Table 8.—*Hauling speed of 3½-ton trucks (make A) with solid tires over a rough road; each entry is the average of a one-hour study*

JOB NO. 41

[Average round-trip speed, 271 feet per minute]

Dippers per load	Hau	Time		Average speed	
		Haul	Return	Haul	Return
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
6.1	700	217.5	123.2	192	342
6.1	550	130.7	85.2	253	388
6.1	500	126.0	83.0	238	362
6.0	420	90.0	76.7	280	329
6.0	420	99.7	81.7	253	309
5.8	400	79.0	59.6	304	403
6.0	400	114.8	84.8	209	283
6.0	400	168.2	85.2	143	282
4.8	360	60.6	41.6	358	520
6.0	360	67.8	54.7	319	395
5.0	350	77.7	48.5	270	433
6.0	350	139.0	69.7	151	301
5.0	320	81.8	99.0	236	195
Total or av. 74.9	5,530	1,452.8	992.9	228	334

JOB NO. 44

[Average round-trip speed, 369 feet per minute]

3.3	1,900	356.7	246.3	320	463
3.0	1,800	267.3	228.3	404	474
3.4	1,800	298.2	209.0	362	508
3.0	1,800	375.0	244.5	288	442
4.0	1,200	201.8	149.8	358	480
3.8	1,100	178.5	143.7	371	460
4.0	1,100	165.2	156.2	401	423
3.2	1,000	271.7	237 7	221	252
4.0	900	174.5	180.5	309	299
4.0	700	134.4	70.8	313	593
4.0	700	147.0	81.0	286	520
4.0	450	67.4	49.8	400	540
4.0	450	93.2	52.6	290	514
4.0	300	59.6	55.4	302	324
3.0	150	53.0	46.3	170	195
Total or av. 54.7	15,350	2,843.5	2,152.9	320	423

Table 9.—*Hauling speed with 1-ton trucks (make C) with pneumatic tires operating over a good road; each entry is the result of a single observation*

[Average round-trip speed, 362 feet per minute]

Dippers per load	Haul	Time		Average speed	
		Haul	Return	Haul	Return
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
2	300	75	45	240	400
2	300	67	40	269	450
2	300	72	52	250	347
2	300	75	55	240	328
2	500	74	75	406	400
2	500	77	99	390	303
2	500	88	71	341	423
2	525	94	90	335	350
2	525	87	100	362	315
2	450	90	79	300	342
2	450	83	80	326	338
2	500	97	91	319	330
2	450	85	74	318	365
2	550	106	99	312	334
2	500	95	91	316	330
2	500	84	78	357	384
2	500	93	80	322	375
1	700	78	80	539	525
1	700	92	72	457	584
1	750	107	79	421	570
Total or av. 1.85	9,800	1,719	1,530	342	384

TABLE 10.—*Hauling speed with 5-ton trucks (make D) with solid tires over a good surface; each entry represents the average for one day's study*

[Average round-trip speed, 508 feet per minute]

Dippers per load	Haul	Time		Average speed	
		Haul	Return	Haul	Return
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
5.0	2,850	284	271	610	630
5.7	2,975	260	239	686	747
7.5	3,175	365	347	522	550
7.7	3,200	332	285	578	674
4.8	3,225	367	341	528	568
7.0	3,250	293	246	665	792
5.7	3,250	424	299	460	652
6.3	3,275	461	344	427	672
4.3	3,350	669	591	301	340
9.3	3,525	509	421	417	504
5.3	3,550	425	343	502	621
4.7	3,575	745	639	288	336
5.0	3,750	444	393	507	573
6.7	3,875	413	332	563	700
6.7	3,900	478	466	490	505
6.3	3,950	436	324	544	732
6.0	4,275	622	519	418	495
Total or av.. 6.1	58,950	7,527	6,400	470	553

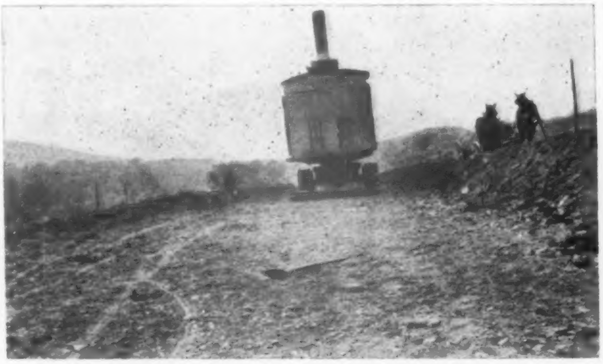
equipment should be used On the other hand, while the presence of a large amount of such material should suggest the use of equipment other than trucks, there are relatively few large projects which have no material of this general nature. If it is decided to use trucks in such a case, dual pneumatic tire equipment is a decided advantage. The trucks can then travel repeatedly over ground which could not be traversed with solid tires.

The cost of using the dual pneumatic tires is doubtless more than that for solid tires where the same rate of production can be maintained with either type but it should be remembered that a very small difference in output will cover the difference in operating cost. With excavation at 50 cents a cubic yard, and the trucks hauling 2 cubic yards per load, a difference of a few loads a day in favor of the dual pneumatic tires will justify their use. Table 7 shows the speed it is possible to maintain under favorable conditions on long-haul work with trucks equipped with these tires.

TRUCK SPEED GOVERNED BY ROAD CONDITIONS

The performance of trucks is governed largely by the supporting power of the ground at the shovel and at the dump. Generally, the traveled way between the shovel and the dump is more compact and easier to maintain. The exact soil condition which will be encountered at the bottom of a deep cut is naturally a matter of conjecture until the work is well under way. With this uncertainty it seems that more stress could well be placed on the necessity of having all trucks equipped with the most favorable type of tires. Observations made on a number of projects on which trucks were used indicate that several which were handled at little or no profit could have been converted into profitable undertakings by merely adjusting this one item in the equipment. Such a change would have enabled the trucks not only to operate over the soft ground but would also have reduced the turning time and materially increased the operating speed, an important item on all long-haul work.

Tables 7 to 10 show the results of observations as to the speed of trucks of various types. In practice the working speed seldom, if ever, reaches the rated speed of the truck. No job has yet been found where the trucks were consistently working at anywhere near their rated full-load speed. The job speed appears to be governed partly by the load but more definitely by the road conditions. Bad going and overloaded trucks are the rule. Overloading appears to be due in part to attempts to counteract the effect of low speed by carrying larger loads. Generally this makes road conditions still worse, necessitating even lower speed, and finally, as the roads become still worse, smaller loads at very low speeds. It appears that this problem can best be solved with adequate tire equipment, proper loads, and reasonable attention to maintenance of the roads. This would more often permit a normal operating speed.



SMOOTH ROADWAY SURFACE LEFT BY A CAREFUL SHOVEL OPERATOR

Tire equipment suited to road conditions on highway construction will considerably simplify keeping the traveled way in good condition. The matter should not, however, rest here. When the hauling must be done over a yielding surface, ruts are inevitable unless a blade grader or drag is kept at work most of the time. Filling depressions before they become large will generally keep the surface in reasonably good condition except in very wet or very dry weather. In dry weather bad places can usually be patched, if an occasional load of moist clay be placed so that it can be bladed gradually into the ruts. The tendency is to put off blading until the ruts become so deep that they obviously hinder the trucks. When this point has been reached, it is difficult, if not impossible, to correct it. There is some danger in filling very deep ruts with a drag or grader because the material is seldom stable until it has been driven over a good many times. The worst holes are hidden so that there is more danger of damaging the trucks immediately after the ruts are filled than there was before. Maintenance to be effective must be used as a preventive rather than as a cure. Next to the use of suitable tires, continuous maintenance is probably the most important item in securing a profitable output where trucks are used.

Road conditions between the shovel and the dump may often be improved by more careful work by the shovel operator and grade foreman. Occasionally a foreman will be found who sets grade targets at the height of the operator's eye, so that the operator can tell at all times just how closely he is cutting to grade and can leave the floor of the cut behind him reasonably smooth and close to grade. Excavation conducted in this manner leaves a much better surface for vehicles to travel over and enables a greater speed to be maintained.

MANY CONTRACTORS BEGIN OPERATION TOO SOON AFTER A RAIN

Another factor in the creation of bad hauling conditions is the operation of trucks too soon after rains. This raises the question of idle time losses which was discussed in connection with the operation of wagons. In principle the solution of the problem is along the same lines, but the relation of idle-time cost to operating cost is here so different that the result is materially changed. Take, as an illustration, a shovel at $50 a day, operations at the dump at $25 a day, and four trucks at $25 a day each—giving a total operation cost of $175 per day. As a rule no stock is used on such a job, and, particularly in the East, no camp is maintained. The only full-time men are the job foreman, the shovel runner, watchman, and perhaps a timekeeper. Ordinarily the idle-time cost will not exceed $30 or $40 a day and the difference between the cost of working and of remaining idle will be from $135 to $145 a day, or roughly four-fifths of the average daily operating cost.

On typical truck-haul jobs it is generally cheaper to remain idle than it is to work unless the output which can be secured is near 80 per cent of that which is required to pay the full operating expenses under normal working conditions. When teams are being used, it is desirable to work whenever it is at all possible, whereas when trucks are being operated profit is almost certain to be reduced by operating before at least three-fourths of the yardage necessary to pay the full cost of normal operation can be secured. This deduction is based only on the relation between idle-time cost and operating cost. It is strongly supported by the fact that beginning operation too soon after rains creates road conditions which slow down subsequent operations and also damage the hauling equipment. These facts strongly emphasize the general observation that there is a prevailing tendency to operate truck jobs too soon after rains with the result that much profit is needlessly dissipated.

Where heavy trucks are used, loading is generally done behind the shovel, but it could frequently be done at the side. In loading at the side there is the problem of truck substitution without delaying the shovel. This can be done readily enough if the bottom of the cut is solid and the shovel has cleaned up carefully. If, however, the bottom of the cut is none too good and the clean-up has been careless, it may be difficult to spot the replacement truck until the loaded truck has moved completely out of the way. This frequently delays the shovel, but if as many as five dipper loads are placed on a truck the shorter shovel cycle is almost certain to more than compensate for any ordinary delay due to the drive-in. The remedy for slow drive-in lies in a careful clean-up and in the maintenance of working conditions suitable for the operation of trucks.

METHOD OF DETERMINING TRUCK SUPPLY DISCUSSED

The number of trucks the contractor should send out with his shovel in order to complete a job at the lowest possible cost deserves much more scientific attention than is usually given the matter. Heavy trucks are usually considered to be worth from $2.50 to $3 per hour. They are too expensive to warrant the use of more than are really necessary. On the other hand a shortage of only one truck on a moderate haul may readily reduce shovel production as much as 20 or 30 per cent. But practically all grading jobs have hauls which vary more or less erratically in length. The number of trucks which a contractor should send to a job is a question which has a very direct relation to the profits.

A general method of determining the number of hauling units which should be sent out on a job with fluctuating hauls was discussed in part 2.[1] These principles are equally applicable to the truck providing data which correctly represent the actual operating characteristics are used. Tables 11 and 12 show the method of finding the cost of completing two particular jobs when varying numbers of three different types of trucks are sent out and maintained with the shovel until the job is completed. The quantities and haul distances are the same as those used in the case of horse-drawn vehicles. It may be well to repeat that the basic data to be used is that relating to the particular job in question and aside from quantities and haul is dependent on the size of the shovel and its rate of operation, the loading, speed, and other operating characteristics of the trucks, together with the relative daily or hourly cost of operating the shovel and the trucks and the distribution of the haul. The actual figures used in these two examples are therefore only illustrative and can not be applied to other jobs unless it is definitely known that all field conditions are practically identical.

Sometimes, especially on large jobs, the hauls may be so distributed that it will prove worth while to vary the number of trucks used from section to section. It may be that the hauls on the first section are such that six trucks are required. The following section, because of shorter hauls or because of more difficult materials, may require only four trucks. At the completion of the first section two trucks should then be either laid up or transferred to other work. It will often be preferable to begin work on the sections with shortest hauls and move in succession to the next longer hauls. This permits a gradual and steady expansion of the organization and is particularly advantageous on jobs with a wide range in haul distances.

Referring to Tables 11 and 12, it will be noted that the larger and more expensive the truck the more important it is to use exactly the proper number. For the light trucks one vehicle more or less than the proper number does not affect the cost so seriously, but for the larger and more expensive vehicles one vehicle either more or less than the optimum is sufficient to affect profits rather seriously, while a difference of two trucks may turn an otherwise profitable job into a definite loss.

Summarizing briefly, the heavy truck is a sturdy, dependable piece of equipment capable of doing good work and a great deal of it. On the other hand, it is an expensive piece of equipment with a large operating expense and the output per truck must be high if its use is to prove profitable. A good many jobs present the appearance of mere replacement of wagons with trucks in which the style of operation still retains all of the characteristics of the wagon job. Under such conditions the use of trucks is apt to be a failure. Trucks can be operated after a fashion even under very adverse conditions, but to work at a profit the conditions must be such that speed as well as carrying capacity can be utilized without serious loss of time due to unnecessary backing, slow turning, and pulling

[1] See Public Roads vol. 9, No. 1, March, 1928.

TABLE 11.—*Determination of most economical number of trucks to send out on a given job where the cost of operating shovel and dump is estimated at $75 per 10-hour day*

Quantity	Haul	Days work at full production (720cu. yds. per day)	Light trucks, pneumatic tires [1]						Heavy-duty trucks, solid tires [2]								Heavy-duty trucks, pneumatic tires [3]					
			Trucks required to maintain full shovel production	9-truck basis	10-truck basis	11-truck basis	12-truck basis	13-truck basis	Trucks required to maintain full shovel production	4-truck basis	5-truck basis	6-truck basis	7-truck basis	8-truck basis	9-truck basis	10-truck basis	Trucks required to maintain full shovel production	3-truck basis	4-truck basis	5-truck basis	6-truck basis	7-truck basis
				Days required						Days required								Days required				
Cu. yds.	*Feet*																					
7, 200	500	10	5. 3	10. 0	10. 0	10. 0	10. 0	10. 0	3. 2	10	10. 0	10. 0	10. 0	10. 0	10. 0	10	2. 5	10. 0	10. 0	10. 0	10. 0	10. 0
18, 720	600	26	5. 9	26. 0	26. 0	26. 0	26. 0	26. 0	3. 4	26	26. 0	26. 0	26. 0	26. 0	26. 0	26	2. 6	26. 0	26. 0	26. 0	26. 0	26. 0
14, 400	900	20	7. 5	20. 0	20. 0	20. 0	20. 0	20. 0	4. 2	20	20. 0	20. 0	20. 0	20. 0	20. 0	20	3. 0	20. 0	20. 0	20. 0	20. 0	20. 0
10, 800	1, 200	15	9. 1	15. 1	15. 0	15. 0	15. 0	15. 0	5. 0	20	15. 0	15. 0	15. 0	15. 0	15. 0	15	3. 4	17. 1	15. 0	15. 0	15. 0	15. 0
5, 760	1, 500	8	10. 7	9. 5	8. 2	8. 0	8. 0	8. 0	5. 8	16	9. 6	8. 0	8. 0	8. 0	8. 0	8	3. 8	10. 6	8. 0	8. 0	8. 0	8. 0
10, 080	1, 800	14	12. 3	19. 0	17. 2	15. 5	14. 3	14. 0	6. 6	30	19. 0	15. 7	14. 0	14. 0	14. 0	14	4. 2	20. 0	15. 0	14. 0	14. 0	14. 0
7, 200	2, 400	10	15. 7	17. 2	15. 5	14. 1	12. 9	11. 9	8. 2	27	16. 0	13. 3	11. 4	10. 0	10. 0	10	5. 0	16. 7	12. 5	10. 0	10. 0	10. 0
7, 200	3, 000	10	18. 7	20. 7	18. 7	17. 0	15. 6	14. 4	9. 7	33	20. 0	16. 7	14. 3	12. 5	11. 1	10	5. 8	20. 0	15. 0	12. 0	10. 0	10. 0
14, 400	4, 000	20	24. 0	53. 4	48. 0	43. 4	40. 0	36. 8	12. 4	80	48. 0	40. 0	34. 3	30. 0	26. 7	24	7. 1	46. 7	35. 0	28. 0	23. 3	20. 0
10, 800	4, 600	15	27. 2	45. 3	40. 8	37. 0	34. 0	31. 5	13. 9	70	42. 0	35. 0	30. 0	26. 2	23. 3	21	7. 9	40. 0	30. 0	24. 0	20. 0	17. 1
Total, 106, 560	....	148	....	236. 2	219. 4	206. 0	195. 8	187. 6	....	332	225. 6	199. 7	183. 0	171. 7	164. 1	158	....	227. 1	186. 5	167. 0	156. 3	150. 1
Coast per day				$183	$195	$207	$219	$231	....	$175	$200	$225	$250	$275	$300	$325	....	$165	$196	$225	$255	$285
Total cost of job				43, 225	42, 783	42, 642	42, 880	43, 336	....	58, 100	45, 120	44, 933	45, 600	47, 218	49, 230	51, 350	....	37, 472	36, 368	37, 865	39, 857	42, 779

[1] Estimate on basis of light trucks at $12 per day to carry 2 dippers per load, round trip speed 500 feet per minute, loading time three-quarters minute; total time constant 2 minutes.
[2] Estimate on basis of heavy-duty trucks at $25 per day to carry 5 dippers per load, round-trip speed 400 feet per minute, loading time 1.9 minutes, and total time constant 3.5 minutes.
[3] Estimate on basis of heavy-duty trucks with pneumatic tires at $30 per day to carry 5 dippers per load at 800 feet per minute, loading time 1.9 minutes, and total time constant 3.5 minutes.

TABLE 12.—*Determination of most economical number of trucks to send out on a given job where the cost of operating shovel and dump is estimated at $75 per 10-hour day*

Quantity	Haul	Days' work at full production (720 cu. yds. per day)	Light trucks [1]						Heavy-duty trucks, solid tires [2]					Heavy-duty trucks, pneumatic tires [3]			
			Trucks required to maintain full shovel production	5-truck basis	6-truck basis	7-truck basis	8-truck basis	9-truck basis	Trucks required to maintain full shovel production	2-truck basis	3-truck basis	4-truck basis	5-truck basis	Trucks required to maintain full shovel production	2-truck basis	3-truck basis	4-truck basis
				Days required						Days required					Days required		
Cu. yds.	*Feet*																
14, 400	500	20	5. 3	21. 3	20. 0	20. 0	20. 0	20. 0	3. 2	31. 6	21. 0	20. 0	20	2. 5	25. 0	20. 0	20
10, 800	600	15	5. 9	17. 6	15. 0	15. 0	15. 0	15. 0	3. 4	25. 6	17. 1	15. 0	15	2. 6	19. 8	15. 0	15
7, 200	700	10	6. 4	12. 8	10. 6	10. 0	10. 0	10. 0	3. 7	18. 5	12. 3	10. 0	10	2. 8	13. 8	10. 0	10
10, 800	800	15	6. 9	20. 8	17. 3	15. 0	15. 0	15. 0	3. 9	30. 0	20. 0	15. 0	15	2. 9	21. 7	15. 0	15
5, 760	900	8	7. 5	11. 9	10. 0	8. 5	8. 0	8. 0	4. 2	16. 8	11. 2	8. 4	8	3. 0	12. 2	8. 0	8
7, 200	1, 100	10	8. 5	17. 0	14. 2	12. 2	10. 7	10. 0	4. 7	23. 7	15. 8	11. 8	10	3. 3	16. 5	11. 0	10
10, 800	1, 200	15	9. 1	27. 2	22. 7	19. 4	17. 0	15. 1	5. 0	37. 5	25. 0	18. 8	15	3. 4	25. 6	17. 1	15
Total, 66, 960	....	93	....	128. 6	109. 8	100. 1	95. 7	93. 1	....	183. 7	123. 4	99. 0	93	....	134. 6	96. 1	93
Cost per day				$135	$147	$159	$171	$183	....	$125	$150	$175	$200	....	$135	$165	$195
Cost to complete job				17, 361	16, 141	15, 916	16, 365	17, 037	....	23, 963	18, 510	17, 325	18, 600	....	18, 171	15, 857	18, 125

[1] Estimate on basis of light trucks at $12 per day carrying 2 dippers per load, round-trip speed 500 feet per minute, loading time three-fourths minute, total time constant 2 minutes.
[2] Estimate on basis of heavy-duty trucks at $25 per day, carrying 5 dippers per load, round-trip speed 400 feet per minute, loading time 1.9 minutes, total time constant 3½ minutes.
[3] Estimate on basis of trucks with dual-pneumatic tires, carrying 5 dippers per load, $30 per day, loading time 1.9 minutes, total time constant 3½ minutes, round-trip speed 800 feet per minute.

out of holes. To make the use of trucks profitable, their characteristics must be studied, the proper type selected, and the job conditions then adjusted and maintained so as to meet these requirements.

LARGE TRACTOR-DRAWN WAGONS NOW USED

Large dump wagons drawn by crawler-type tractors have recently come into considerable use with power shovels. The merit of this combination appears to be due to the following facts: (1) The crawler-type tractor can be operated effectively over a wide range of road conditions such as are found in grading work; (2) it can be maneuvered readily on steep grades, over rough or soft ground and among stumps, rocks, and other obstructions; (3) it can maintain a relatively high draw-bar pull under these conditions and can haul comparatively large loads; and (4) the wagons which have been studied were strongly constructed and well adapted to operate under severe field conditions and were equipped with a simple and effective dumping mechanism.

Under normal working conditions a heavy tractor can draw two of these dump wagons, each having a capacity of 5 or 6 cubic yards. If the haul is down very heavy grades, it is sometimes necessary to limit the train to one wagon because at present wagons are not equipped with brakes. Tables 13 to 17, inclusive, indicate that where ground conditions are fair and the road of sufficient width, two wagons can be handled almost as speedily as one, not only in the operations of dumping, turning, and maneuvering, but also in the direct haul. The use of two wagons is clearly an advantage if all loading is done at the rear of the shovel instead of the more logical method of loading the vehicles at the side. A one-wagon train can be backed with ease and dispatch, but to back a two-wagon train requir es con

siderable skill and time. A partial solution of this difficulty might be found in the use of a larger shovel. The handicap of a long swing would still remain, but a smaller number of dippers would be required to load each train.

FAST TURNING AND DUMPING POSSIBLE WITH TRACTOR TRAINS

The various operations of turning, dumping, and maneuvering are comparatively fast in the hands of a skillful operator. The exact time for each of these operations is shown more fully in Tables 13 to 16. Tables 14 to 17 show the hauling speed for various lengths of haul and under the varying conditions on different jobs. These tables will indicate to some extent what can be expected from this type of equipment as well as the amount of the time losses most likely to be chargeable to its use.

Of the items which make up the time constant, it will be observed that the loading time is long. This is inevitable on account of the large amount of material carried per load. The loading time is usually from five to seven minutes for a train of two 5-yard wagons. With a standard ¾-yard shovel, from 7 to 10 dippers are required to load each wagon, and, if the shovel is working at a rate of three dipper loads per minute, from two and one-third to three and one-third minutes will be taken up in loading each wagon. If the cut is narrow so that the turning radius is short it may be necessary to use the shovel in getting the second wagon into loading position as on short turns it does not follow around perfectly. On wide roads this extra operation is not necessary, nor is it required in loading at the side of the shovel. Any conditions which extend the dipper cycle beyond 20 seconds—stiff clay, badly shot rock, stumps, etc.—will also extend the loading period so that digging conditions must be

TABLE 13.—*Time constant studies of crawler tractors, each drawing one 5-yard steel wagon. Loading done by a ¾-yard shovel*

[Time constant, 219.1 seconds]

Dippers per load	Loading	Waiting at dump	Turning at dump	Dumping	Turning at shovel
Number	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*
6	152	----------	14	7	16
6	151	----------	11	9	10
7	168	----------	9	10	13
5	121	----------	12	9	13
7	177	----------	8	8	15
7	179	----------	9	8	15
7	165	----------	14	12	14
7	182	----------	19	15	14
7	174	----------	44	10	15
7	167	----------	14	7	16
8	209	----------	17	7	14
7	167	----------	15	10	11
7	180	14	22	10	14
8	188	----------	15	7	12
8	216	13	14	8	15
7	195	10	17	7	22
8	204	----------	17	9	14
8	182	----------	16	8	16
8	209	----------	15	9	17
7	175	----------	10	6	20
Av. 7.1	178	1.9	15.6	8.8	14.8

TABLE 14.—*Comparison of operating speed of crawler tractors drawing 1-wagon and 2-wagon trains*

The wagons were 5-yard capacity and were loaded by a ¾-yard shovel. Operation in late fall and winter over roads in fair and poor condition]

Operation	Time for 1-wagon train [1]	Time for 2-wagon train [2]
	Seconds	*Seconds*
Loading	186.0	398.5
Waiting at dump	67.6	86.3
Turning at dump	20.8	22.8
Dumping load	17.4	20.7
Turning at shovel	21.0	17.5
Spotting second wagon	----------	13.8
Total	312.8	559.6

[1] Results are the average for 153 round trips. Average round-trip speed on hauls from 300 to 3,000 feet was 300 feet per minute.

[2] Results are the average for 84 round trip. Average round-trip speed on hauls from 200 to 2,000 feet was 285 feet per minute.

TABLE 15.—*Typical studies of operation of crawler tractors drawing two 5-yard wagons. Loading done by ⅞-yard shovels*

JOB No. 39

Haul	Loading	Hauling to dump	Turning at dump	Waits and delays	Dumping load	Returning to shovel	Turning at shovel	Speed loaded [1]	Speed empty [1]
Most of hauling over rough and rocky roads with steep grades									
Feet	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*
1,200	288	275	22	37	19	292	14	261	246
1,400	307	220	19	30	18	250	14	380	336
1,425	346	312	19	48	9	298	12	274	287
1,425	291	234	23	44	12	279	17	365	306
1,425	324	247	13	32	8	268	13	346	319
1,450	287	256	22	42	13	272	21	339	320
1,450	395	255	17	94	14	259	53	341	336
1,450	254	261	21	75	15	260	55	333	334
1,450	361	288	28	72	19	283	19	302	307
1,500	272	319	18	268	15	317	14	282	283
1,500	284	269	12	34	8	322	24	334	279
1,500	252	322	19	82	10	320	14	279	281
1,500	282	288	17	46	10	312	14	312	288
1,500	346	263	18	58	16	299	14	341	300
1,550	277	292	25	92	14	303	16	318	306
1,550	288	318	16	74	29	319	16	292	291
1,600	300	390	20	45	21	421	10	246	228
1,650	298	306	19	34	17	306	8	323	323
1,650	320	372	21	28	38	390	13	266	253
1,650	322	359	21	38	35	364	18	276	272
Total, 29,825	6,094	5,746	390	1,263	340	6,134	378	--------	------
Av. 1,491	305	287	19.5	63	17	307	19	311	292
Short hauls over rough and rocky ground. Shovel operating in frozen ground									
350	544	105	28	33	24	175	28	200	120
350	398	102	34	548	22	192	32	206	110
375	422	122	28	112	18	181	29	185	124
375	727	130	29	12	26	184	28	173	122
400	375	124	31	48	23	190	39	193	126
400	491	113	19	14	18	183	28	212	131
425	365	116	28	21	15	170	40	220	150
450	405	118	26	5	28	217	25	229	125
500	381	145	35	5	30	172	31	207	174
550	511	156	25	9	20	213	26	212	155
Total. 4,175	4,619	1,231	283	807	224	1,877	304	--------	------
Av. 417	462	123	28	81	22	188	30	204	133

JOB NO. 35

Haul	Loading	Hauling to dump	Turning at dump	Waits and delays	Dumping load	Returning to shovel	Turning at shovel	Speed loaded [1]	Speed empty [1]
Hauling over road in fair to poor condition with steep grades									
875	307	195	22	-------	7	229	19	270	229
900	305	207	30	30	11	198	12	261	272
950	273	215	13	40	10	205	15	270	283
950	285	207	22	63	5	204	13	280	284
1,000	288	186	17	-------	34	207	11	322	290
1,050	312	208	24	80	10	214	13	302	294
1,100	304	214	22	-------	12	228	12	308	289
1,150	285	203	26	-------	11	252	22	340	274
1,200	335	242	16	-------	14	241	10	297	298
1,250	361	250	22	-------	19	257	9	300	292
1,300	299	266	26	22	16	304	12	293	255
1,350	332	275	27	195	28	321	27	295	252
1,375	300	275	29	143	25	301	19	300	274
1,400	347	277	28	99	31	317	33	303	265
2,000	294	318	36	-------	23	412	28	378	292
2,050	365	366	23	65	30	410	11	336	300
2,050	314	357	29	99	35	425	17	345	289
2,100	372	358	27	45	38	443	21	352	284
2,100	457	409	25	103	36	441	16	308	286
2,150	409	383	24	34	29	423	15	336	305
2,150	298	431	17	35	23	445	11	300	290
2,200	323	403	20	54	24	410	12	327	323
2,200	292	425	21	177	26	466	20	310	283
2,250	309	416	22	76	12	438	10	324	307
2,300	276	425	29	179	34	458	13	325	301
Total. 39,400	8,042	7,511	597	1,539	543	8,249	401	--------	------
Av. 1,576	321.7	300.2	23.8	61.5	21.7	329.9	16	315	286

[1] On both jobs the haul was down a grade, resulting in a higher speed while loaded than while empty.

TYPICAL OPERATION WITH TRACTORS HAULING LARGE-CAPACITY DUMP WAGONS

TABLE 16.—*Hauling speed of crawler tractors with one 5-yard wagon with road conditions varying from good to very poor with deep mud*

Round trips timed	Distance	Haul to dump	Speed loaded	Return to shovel	Speed empty
Number	*Feet*	*Seconds*	*Feet per minute*	*Seconds*	*Feet per minute*
6	475	116.0	246	153.0	186
9	550	137.0	241	161.0	205
8	300	73.0	247	83.0	217
8	390	87.5	268	96.0	244
6	510	107.7	284	118.3	258
3	700	138.7	303	156.7	268
6	375	104.5	215	134.1	167
2	550	118.0	280	130.0	254
10	90	46.4	148	42.8	164
10	740	199.2	223	148.7	298
7	1,050	241.7	260	207.3	303
5	1,025	202.2	305	184.0	334
6	785	215.7	219	142.1	331
Total. 86	47,215	11,531.4	----------	11,182.2	----------
Average----	----------	----------	246	----------	253

fairly good and ample turning space must be available if a two-wagon train is to be loaded every six minutes with the ordinary ¾-yard shovel.

At the dump, layer or end dumping can be used with almost equal facility. With ordinary materials the load as it is dumped is spread over a length of some 20 feet. In layer dumping these piles can be spread either by a heavy blade grader or by a bulldozer, and the material compacts without serious difficulty under the tractors and wagons as the work progresses. Where this practice is followed the dumping time is almost negligible as the train need hardly come to a full stop in order to make the dump. Dumping the load is

TABLE 17.—*Hauling speed of crawler tractors with one 5-yard wagon with road conditions as noted*

Dippers per load	Length of haul	Time		Average speed		Remarks
		Haul	Return	Haul	Return	
Number	*Feet*	*Seconds*	*Seconds*	*Feet per minute*	*Feet per minute*	
8	300	73	89	247	203	Haul down 8 per cent grade with mud hub deep.
8	300	60	74	300	243	
8	300	65	76	277	237	
7	300	64	74	282	243	
9	300	82	83	220	214	
6	300	72	92	250	196	
7	200	71	65	169	185	Muddy, grade light.
6	200	69	64	174	188	
8	200	74	65	162	185	
7	200	79	62	152	194	
7	150	51	57	177	158	Road good, easy grades; more trains on job than needed.
7	150	52	51	172	177	
7	150	47	61	192	145	
8	150	52	57	172	158	
6	[1] 50	38	36	79	83	Road good, easy grades.
6	[1] 50	43	46	70	65	
7	[1] 50	37	42	81	72	
6	[1] 50	40	39	75	77	
7	575	140	215	246	140	Mud hub deep.
7	575	155	200	222	155	
7.1	4,350	1,206	1,251	216	209	

[1] Not included in averages.

often merely a part of the general operation of turning at the dump. Where end dumping is practiced, the loads are dropped in the same general way as the turn is being made and then a bulldozer or other equipment is used to push the dumped piles over the bank.

Turning is fast. Crawler-type tractors can usually work close to the edge of a fill, so that a train of two wagons can ordinarily be turned on a 25-foot embank-

ment without backing. Turning time at both the dump and the cut is therefore low, as shown in Tables 13 to 15. At the shovel the turning is usually done so quickly that the drive-in can be made within a normal dipper cycle. Under fair operating conditions the average time required for turning at the dump, dumping the load, and turning again at the shovel, should not exceed a total of one minute, and under adverse conditions should not exceed a total of one and one-half minutes.

PRODUCTION OBTAINED BY LARGE LOADS RATHER THAN SPEED

The rate of travel of tractor trains is only a little greater than that of teams—from 275 to 325 feet per minute under favorable conditions, and it may fall as low as 200 feet per minute under adverse conditions. Because of this low speed and the wide distribution of the tractor load on the road, the cost and difficulty of maintaining a satisfactory roadway is seldom as great as is found necessary for the successful operation of heavy trucks. Trucks must normally obtain their production by maintaining a good rate of speed—8 to 10 miles an hour—when carrying a reasonable load. The tractor train obtains its production by taking out a large load at a low hauling speed but with little time loss in dumping and turning.

Dependability is, of course, an important item in selecting hauling equipment and is particularly so in the case of tractor trains as many outfits use only two or three units and the failure of one will reduce the output by 33 or 50 per cent. During the studies few delays were noted and these were very largely chargeable to carelessness or indifference on the part of the operators. From extended observation it is believed that only high-grade operators should be employed and systematic attention should be given to maintaining proper operation practices and to keeping the equipment in first-class condition.

NUMBER OF HAULING UNITS USED OF GREAT IMPORTANCE

Use of a proper number of hauling units is of outstanding importance. A tractor and two 5-yard wagons represents quite an investment. The operating cost per train is also high and is made up approximately as follows:

Driver	$7
Depreciation	13
Gasoline and oil	7
Repairs	3
Total	30

TABLE 18.—*Analysis to determine the most economical number of tractor trains for use on a given job*

Quantities	Haul	Days work at full shovel production	Number of 2-wagon tractor trains [1]: Number required to maintain full shovel production	1	2	3	Number of 1-wagon tractor trains [2]: Number required to maintain full shovel production	2	3	4	5
				Days required				Days required			
Cubic yards	*Feet*										
14,400	500	20	1.9	38.0	20.0	20.0	2.6	26.1	20.0	20.0	20.0
10,800	600	15	2.0	30.0	15.0	15.0	2.8	21.2	15.0	15.0	15.0
7,200	700	10	2.1	21.1	10.6	10.0	3.1	15.3	10.2	10.0	10.0
10,800	800	15	2.2	33.3	16.7	15.0	3.3	24.6	16.4	15.0	15.0
5,760	900	8	2.3	18.7	9.3	8.0	3.5	14.0	9.5	8.0	8.0
7,200	1,100	10	2.6	25.6	12.8	10.0	4.0	19.7	13.2	10.0	10.0
10,800	1,200	15	2.7	40.0	20.0	15.0	4.2	31.2	20.8	15.6	15.0
Total 66,960		93		202.7	104.4	93.0		152.1	105.1	93.6	93.0
Cost per day				$105	$135	$165		$129	$156	$183	$210
Cost to complete job				21,284	14,094	15,345		19,621	16,396	17,129	19,530

[1] Tractors drawing two 5-cubic yard steel wagons, $30 per day, speed 300 feet per minute, loading time 6 minutes per train, and total time constant 8 minutes.
[2] Tractors drawing one 5-cubic yard steel wagon, $27 per day, speed 300 feet per minute, loading time 3 minutes, total time constant 4½ minutes.

TABLE 19.—*Analysis to determine the most economical number of units for use on a given job with considerable variation in haul distance*

Quantities	Haul	Days work at full shovel production	Number of 2-wagon tractor trains [1]: Number required to maintain full shovel production	2	3	4	5	6	Number of 1-wagon tractor trains [2]: Number required to maintain full shovel production	3	4	5	6	7	8
				Days required						Days required					
Cubic yards	*Feet*														
7,200	500	10	1.9	10.0	10.0	10.0	10.0	10.0	2.6	10.0	10.0	10.0	10.0	10.0	10.0
18,720	600	26	2.0	26.0	26.0	26.0	26.0	26.0	2.8	26.0	26.0	26.0	26.0	26.0	26.0
14,400	900	20	2.3	23.3	20.0	20.0	20.0	20.0	3.5	23.3	20.0	20.0	20.0	20.0	20.0
10,800	1,200	15	2.7	20.0	15.0	15.0	15.0	15.0	4.2	20.8	15.6	15.0	15.0	15.0	15.0
5,760	1,500	8	3.0	12.0	8.0	8.0	8.0	8.0	4.8	12.9	9.7	8.0	8.0	8.0	8.0
10,080	1,800	14	3.3	23.3	15.6	14.0	14.0	14.0	5.5	26.1	19.3	15.4	14.0	14.0	14.0
7,200	2,400	10	4.0	20.0	13.3	10.0	10.0	10.0	6.8	22.8	17.1	13.7	11.4	10.0	10.0
7,200	3,000	10	4.7	23.3	15.6	11.7	10.0	10.0	8.1	27.2	20.4	16.3	13.6	11.7	10.2
14,400	4,000	20	5.8	57.8	38.5	28.9	23.1	20.0	10.4	69.3	51.9	41.6	34.6	29.6	26.0
10,800	4,600	15	6.4	48.3	32.2	24.2	19.3	16.1	11.5	58.6	44.0	35.2	29.3	25.1	22.0
Total, 106,560		148		264.0	194.2	167.8	155.4	149.1		297.0	234.0	201.2	181.9	169.4	161.2
Cost per day				$135	$165	$195	$225	$255		$156	$183	$210	$237	$264	$291
Total cost of job				35,640	32,043	32,721	34,965	38,021		46,332	42,822	42,252	43,110	44,722	46,909

[1] Tractor to draw two 5-cubic yard steel wagons, $30 per day, speed 300 feet per minute, loading time 6 minutes, total time constant 8 minutes.
[2] Tractors drawing one 5-cubic yard steel wagon, $27 per day, speed 300 feet per minute, loading time 3 minutes, total time constant 4½ minutes.

A high output per unit is necessary to justify this expenditure. Obviously, the minimum hauling equipment which can maintain full shovel production is two trains. Under ordinary conditions two trains of two wagons each should be able to maintain full production for a $\frac{3}{4}$-yard shovel up to a haul of 600 or 700 feet, depending on the exact rate of shovel operation. The minimum cost per day for a grading outfit provided with this equipment is about $135 (shovel, $50; two trains, $60; dump, $25). At a haul of about 700 or 800 feet a third unit will be needed, and if there is much hauling beyond 1,600 or 1,800 feet a fourth train may prove desirable. Tables 18 and 19 are developments of the same data as those given previously in connection with the discussion of team and truck hauling. They show how the total cost of the job is affected by using various numbers of one-wagon and two-wagon tractor trains. It will be noted that the use of one-wagon trains is much more expensive than two-wagon trains except for hauls less than about 400 feet. Using this method of analysis and the prices investigation and experience indicate for the particular job, the contractor can determine within reasonable limits not only what type of equipment is preferable but also the number of units which will prove most economical to place on the job.

Where two-wagon trains are used, each additional hauling unit after the first two extends the limit to which full shovel production can be maintained considerably—under favorable operating conditions about 900 feet—and if shovel operation is slow or difficult the distance may be much greater. The daily operating cost of each train is high and it is not always easy to decide just when an additional train would prove economical. Assume that two tractor trains of two wagons each can maintain full shovel production up to a haul of 600 feet, and that three trains could maintain full production up to a haul of 1,500 feet, and that the daily cost of operating with the two trains is $135 per day and that the additional train will cost $30 per day. An additional unit should be added at the point where increased production is proportional to the increased cost. In this case it should be added at the haul distance corresponding to the theoretical train requirement, N, as determined by equating the cost ratio to the production ratio, $\frac{135}{165}=\frac{2}{N}$, which results in the value, $N=2.44$ trains. The additional train requirement varies from 0 to 1 over a distance of 900 feet and the theoretical requirement of 0.44 of a train will be at a distance of 396 feet. The additional two-wagon train should therefore be added at a haul of approximately 1,000 feet.

Under the conditions prevailing on the jobs given in Tables 18 and 19 there is a decided advantage in using two-wagon trains, particularly on the long-haul job in Table 19. No allowance has been made in the examples for the possible saving on short hauls where a portion of the equipment will not be needed. Some saving is possible in operating expense, even though drivers must be paid. Where horses and wagons are used, feeding the horses and the drivers when work is shut down generates an idle-time cost which is at least half of the operating cost. With tractors or trucks the machines can be protected to avoid depreciation costs; there is no charge for gasoline, oil, or repairs and the driver may be laid off if the shutdown for that unit is likely to be long. It seems to be practical to carry mechanical hauling equipment much more nearly in balance with the maximum length of haul than can be done where teams are used.

On the other hand, profits are seriously affected by using more tractors than are actually needed at any particular time. If two trains can haul all the material the shovel can dig and three are used, then the daily cost of operation is raised from $135 to $165. If full shovel production is at the rate of 720 cubic yards per day, then with two trains working, the unit cost is $18\frac{3}{4}$ cents per cubic yard, while with three trains working it will be $22\frac{11}{12}$ cents per cubic yard, an increase of over 22 per cent.

The use of too few hauling units may affect profits even more than the use of too many. In the case given in Table 18 the most advantageous number of two-wagon trains is two. The use of only one train would increase the cost of the job nearly $7,200, and the use of one train more than the proper number would increase the cost about $1,250. With one-wagon trains, three is the most advantageous number, and if either two or four are used the cost is increased $3,225 and $733, respectively.

The advisability of laying off surplus units at any time depends entirely on the frequency with which haul distances fluctuate. Opportunities will exist to a considerable degree on some jobs, while on others they will be entirely absent. In making the calculations for any particular job these facts should be kept in mind and all possibilities utilized. On some of the jobs studied where two-wagon trains were used, the trains were reduced to one-wagon on the shorter hauls. The net operating cost remained nearly as high as before.

NOT ADVISABLE TO WORK WITH TRACTOR TRAINS WHEN WEATHER CONDITIONS REDUCE PRODUCTION MUCH BELOW NORMAL

Where tractor trains are used for hauling, the direct cost of keeping the outfit idle is so low that there is more danger of operating too soon after rain than there is of delaying too long. When idle the tractor trains as well as the shovel generate practically no cost except interest which is a relatively small factor as compared with the total daily operating cost. When working, each train costs about $30 a day. Full-time men about the shovel and general job overhead generate a cost not far from $40 a day. If three trains are normally required in order to maintain production, the daily cost of operating is about $165. Under such conditions (providing no penalties are involved) a yardage of nearly three-fourths of that required to pay the cost of normal production is necessary in order to justify working at all.

There is no great danger that working too soon after rains will create road conditions likely to interfere with the work for some days. Road conditions must be such that they would be considered bad for most types of hauling equipment before the rate of operation of tractor trains is much affected. How soon work shall begin after a storm is, in general, dependent on the conditions at the dump and at the shovel rather than on the condition of the roadway. The fact that this type of hauling equipment can operate successfully where hauling conditions are below normal does not mean that attention to the roadway can safely be neglected. The increased cost of fuel and the wear and tear on the equipment on a bad road is naturally much greater than on a good road. If the job is to be made to yield a satisfactory profit, high-grade management is perhaps even more necessary where tractors and heavy wagons are employed than where ordinary team hauling is used.

MOTOR-VEHICLE REGISTRATIONS, 1927 [1]

[Compiled from reports of State authorities]

State	Registered motor vehicles, individually and commercially owned [2]: Total registered motor cars and trucks	Passenger automobiles, taxis, and busses	Motor trucks and road tractors	Other registered vehicles: Trailers [3]	Motor cycles	Tax-exempt official motor cars and motor cycles: United States cars	State and local cars	Motor cycles (official)	Number of licenses or permits (autos): Dealers	Operators	Chauffeurs	Total registered motor cars and trucks, 1926	Year's change in motor-vehicle registration: Number increase or decrease (−)	Per cent	State
Alabama	243,539	211,633	31,906	1,472	420	167			3,919		1,630	225,930	17,609	7.8	Alabama.
Arizona	81,047	79,802	1,245		271	176	815		212	400	401	73,682	7,365	10.0	Arizona.
Arkansas	206,568	174,524	32,044	1,977	303	39	736	21	479		4,932	209,419	−(2,851)	−1.4	Arkansas.
California	1,693,195	[4] 1,479,411	[4] 213,784	34,126	9,444	1,217	[5] 23,214	461	3,270	129,792	111,193	1,600,475	92,720	5.8	California.
Colorado	268,492	245,107	23,385	88	1,362	283						248,613	19,879	8.0	Colorado.
Connecticut	281,521	238,509	43,012	150	3,083	71	2,459	281	5,600	[6] 323,881		263,235	18,286	6.9	Connecticut.
Delaware	47,124	38,037	9,087	243	313	44			438	[6] 51,945		44,834	2,290	5.1	Delaware.
Florida	394,734	332,979	[7] 61,755	[7] 1,000	1,243	75	3,451	206	2,547		4,949	401,562	−(6,828)	−1.7	Florida.
Georgia	300,635	262,630	38,005		909	934			792		2,553	277,468	23,167	8.4	Georgia.
Idaho	101,336	91,306	10,030	186	440	103	1,210		406		476	94,760	6,576	6.9	Idaho.
Illinois	1,438,985	[4] 1,254,421	[4] 184,564	3,489	6,135	979	(8)		4,594		100,398	1,370,503	68,482	5.0	Illinois.
Indiana	813,637	697,359	116,278	6,599	3,501	3,184	4,083		2,584		39,212	277,326	41,311	5.3	Indiana.
Iowa	704,203	649,309	54,894	170	1,787	44	2,827		2,531	2,964		698,998	5,205	.7	Iowa.
Kansas	501,901	447,273	54,628		1,218	192	2,360		2,525			491,276	10,625	2.2	Kansas.
Kentucky	285,621	255,892	29,729		693	90	1,742	59	1,051		8,410	281,557	4,064	1.4	Kentucky.
Louisiana	255,000	216,000	39,000	3,500	510	209			487		14,177	239,500	15,500	6.5	Louisiana.
Maine	163,623	132,927	30,696	1,012	1,245	64	1,173	66	1,297	188,975	7,309	151,486	12,137	8.0	Maine.
Maryland	270,935	265,768	5,167	616	2,415	1,969	950		6,788	33,814	40,679	252,852	18,083	7.1	Maryland.
Massachusetts	694,107	614,359	79,748	443	7,245	556	800		2,048	102,285		690,190	3,917	.6	Massachusetts.
Michigan	1,154,773	[4] 998,781	[4] 155,992	17,853	3,585	371	(8)		2,128	220,954	76,483	1,118,785	35,988	3.2	Michigan.
Minnesota	646,682	565,401	81,281	3,286	2,295	252	2,450		2,087		17,988	630,285	16,397	2.6	Minnesota.
Mississippi	218,043	196,239	21,804	2,317	83	74			656			205,200	12,843	6.2	Mississippi.
Missouri	682,419	610,303	72,116	1,739	1,835	311	1,428	3	2,387	5,230	26,269	654,554	27,865	4.2	Missouri.
Montana	112,735	94,733	18,002		156	229	1,158	9	481		338	103,958	8,777	8.4	Montana.
Nebraska	373,912	[4] 342,357	[4] 31,555	1,828	1,109	226	1,029		3,052			366,773	7,139	1.9	Nebraska.
Nevada	25,776	20,414	5,362	104	99	42			533			24,014	1,762	7.3	Nevada.
New Hampshire	96,009	83,415	12,594	565	1,387	22			541	73,474	43,242	89,001	7,008	7.9	New Hampshire.
New Jersey	712,396	586,510	125,886	1,827	6,857	708	6,294	913	2,917	814,593	6,422	651,415	60,981	9.4	New Jersey.
New Mexico	59,291	57,643	1,648	193	170	156	630		170			54,996	4,295	7.8	New Mexico.
New York	1,937,918	1,624,535	313,383	6,936	16,347	1,666	12,116	1,262	4,482	1,701,383	616,025	1,815,434	122,484	5.7	New York.
North Carolina [9]	[9] 430,499	390,223	40,276	1,618	1,194	429	5,419		6,330			[9] 385,047	45,452	11.8	North Carolina.
North Dakota	160,701	144,830	15,871		277	3						157,822	2,879	1.8	North Dakota.
Ohio	1,570,734	1,374,402	196,332	12,134	7,749	2,362	9,067		26,997			1,480,246	90,488	6.1	Ohio.
Oklahoma	503,126	437,776	65,350		1,200	530						499,938	3,188	.6	Oklahoma.
Oregon	244,572	223,582	20,990		2,030	141	1,132		604	39,355	15,769	233,568	11,004	4.7	Oregon.
Pennsylvania	1,554,915	1,354,548	200,367	3,780	14,267	1,383	942		28,347	1,564,161		1,455,184	99,731	6.9	Pennsylvania.
Rhode Island	118,014	98,861	19,153	57	1,250	56	671	87	300	136,860		110,746	7,268	6.6	Rhode Island.
South Carolina	199,635	179,571	20,064	1,387	325	91			508			181,189	18,446	10.2	South Carolina.
South Dakota	169,552	153,019	16,533		229	85	1,019					168,230	1,322	.8	South Dakota.
Tennessee	294,567	269,086	25,481	(3)	904	132	2,914		632			279,639	14,928	5.3	Tennessee.
Texas	1,111,407	996,397	115,010	9,826	3,081	2,505			3,323	41,775	11,490	1,049,869	61,538	5.9	Texas.
Utah [10]	93,976	80,731	13,245		531	173						85,380	8,596	10.1	Utah.
Vermont	79,527	73,308	6,219		601	28			658			74,063	5,464	7.4	Vermont.
Virginia	337,607	288,666	48,941	466	2,025	1,141		253	2,950		8,450	322,614	14,993	4.6	Virginia.
Washington	384,583	326,667	57,916	2,072	2,501	637	4,682	144	4,879	397,975		363,279	21,304	5.9	Washington.
West Virginia	245,819	217,689	28,130	392	1,431	33	1,862		13,701	61,600	25,200	227,836	17,983	7.9	West Virginia.
Wisconsin	698,289	609,795	88,494		2,963	92	668	79	2,949			662,282	36,007	5.4	Wisconsin.
Wyoming	51,955	45,539	6,416		134	209	257		306			49,883	2,072	4.2	Wyoming.
District of Columbia	111,680	98,162	13,518		1,151	837	2,131	212	1,958	57,014	1,581	111,497	183	.2	District of Columbia.
Total	23,127,315	20,230,429	2,896,886	123,451	120,303	[11] 33,179	101,689	4,056	155,444	5,948,430	1,185,576	22,001,393	1,125,922	5.1	Total.

[1] All States report for calendar year except North Carolina which reports only 6 months totals (July 1 to Dec. 31), as their fiscal year for registration ended June 30.

[2] The first 3 columns record the regularly registered motor cars and trucks which pay the regular license fees eliminating reregistrations and registration of cars owned by nonresidents. Some States, as noted, classify busses with trucks. Tables showing the extent and kinds of bus service (from nongovernment sources) can be found in the February, 1928, issue of "Bus transportation."

[3] Some States include trailers with motor trucks, other States do not register trailers.

[4] Busses included with trucks.

[5] Includes over 8,000 cars and trucks of public-service corporation exempt by law.

[6] Includes chauffeurs.

[7] Trailers (1,000 estimated) excluded from trucks.

[8] Official cars included in first 3 columns as $2 fee charged.

[9] Last six months of year's registration only as year commenced July 1.

[10] Preliminary data, subject to revision.

[11] As reported in 1925 by Bureau of Budget, and includes 7,959 "Cars-at-large," not allocated to any State.

MOTOR VEHICLE REGISTRATION FEES, ETC., 1927 [1]

[Compiled from reports of State authorities]

State	Total gross receipts	Registration receipts [2]: Motor car receipts: Total from motor cars	Passenger cars and busses	Trucks and tractors	Other vehicles: Trailers	Motorcycles	Miscellaneous receipts: Dealers' license	Chauffeur and operator permits	Other miscellaneous	Disposition of gross receipts: Collection and administration	For rural highway purposes: State highways	Local roads	State and county road bonds	For other purposes	State
Alabama	$3, 127, 000	$3, 109, 976					$3, 919	$8, 246	$4, 859	$125, 956	$843, 850	$609, 765	$1, 547, 429		Alabama.
Arizona	454, 429	443, 084				$531	3, 356	1, 528	5, 930		454, 429				Arizona.
Arkansas	3, 662, 272	3, 619, 482					5, 469	23, 338	13, 983	73, 246	805, 700	476, 095	[3] 2, 307, 231		Arkansas.
California	8, 796, 348	7, 492, 228	$4, 851, 767	$2, 640, 461	$258, 980	33, 735	45, 858	290, 323	675, 224	1, 243, 924	3, 775, 453	3, 775, 453		[4] 1, 518	California.
Colorado	1, 600, 222	1, 499, 784	1, 248, 325	251, 459	1, 410	2, 303			96, 725	80, 011	760, 106	760, 105			Colorado.
Connecticut	6, 805, 664	5, 196, 922	3, 894, 856	1, 302, 066	274	14, 121	72, 776	979, 629	541, 942		6, 805, 664				Connecticut.
Delaware	846, 289	673, 682	489, 004	184, 678	3, 619	1, 284	7, 685	158, 637	1, 382		846, 289				Delaware.
Florida	5, 692, 128	5, 600, 653	4, 077, 130	1, 523, 523		5, 971	33, 860	9, 325	42, 319	584, 154	3, 829, 579	1, 276, 526		[5] 1, 869	Florida.
Georgia	3, 712, 978	3, 658, 646	3, 039, 048	619, 598		4, 222	40, 260	4, 998	4, 852	114, 730	3, 598, 248				Georgia.
Idaho	1, 502, 185	1, 458, 694	1, 211, 031	247, 663	3, 793	2, 195	24, 225	952	12, 326		156, 269	1, 345, 916			Idaho.
Illinois	14, 839, 593	13, 929, 037	10, 635, 412	3, 293, 625	61, 930	20, 644	89, 860	353, 472	384, 650		9, 191, 015		5, 606, 010	[6] 42, 568	Illinois.
Indiana	5, 430, 806	5, 069, 422	3, 914, 846	1, 154, 576	31, 406	6, 414	52, 030	36, 955	234, 579	251, 341	5, 179, 465				Indiana.
Iowa	10, 371, 699	9, 742, 671	8, 785, 993	956, 678	3, 322	6, 354	78, 604	77, 593	463, 155	414, 070	9, 604, 549	353, 080			Iowa.
Kansas*	6, 518, 622									252, 822	3, 934, 480	2, 331, 320			Kansas.*
Kentucky	4, 365, 062	4, 304, 022	3, 375, 500	928, 522		5, 262	29, 888	16, 143	9, 747	224, 289	3, 676, 512	464, 261			Kentucky.
Louisiana*	4, 199, 347										4, 199, 347				Louisiana.*
Maine	2, 558, 046	1, 980, 811	1, 535, 384	445, 427	3, 375	6, 733	48, 683	405, 848	112, 596	201, 546	[7] 1, 370, 251		986, 249		Maine.
Maryland	2, 987, 912	2, 347, 223	2, 070, 731	276, 492	16, 029	10, 933	31, 349	189, 665	392, 713	298, 791	2, 151, 297			[8] 537, 824	Maryland.
Massachusetts	13, 136, 442	10, 557, 782	7, 318, 651	3, 239, 131	19, 468	32, 177	60, 990	1, 628, 188	837, 837	1, 266, 525	10, 821, 659		1, 048, 258		Massachusetts.
Michigan	17, 984, 210	16, 527, 569	12, 464, 719	4, 062, 850	200, 949	13, 658	94, 568	249, 812	897, 654	[9] 1, 117, 214	9, 784, 936	6, 000, 000	[3] 1, 082, 060		Michigan.
Minnesota	10, 233, 644	10, 110, 633	8, 210, 901	1, 899, 732	14, 277	8, 781	38, 535	20, 330	41, 088		6, 449, 904		[3] 3, 763, 410	[6] 20, 330	Minnesota.
Mississippi	2, 556, 627	2, 220, 942							335, 685	125, 602	202, 077	2, 228, 948			Mississippi.
Missouri*	8, 253, 009									401, 822	[10] 2, 715, 162		5, 136, 025		Missouri.*
Montana	1, 136, 103	1, 039, 235	855, 491	183, 744		1, 087	37, 078	676	58, 027	30, 858		1, 105, 245			Montana.
Nebraska	3, 740, 553	3, 574, 994	3, 016, 632	558, 362	5, 079	3, 728	43, 919		112, 833	111, 983	1, 088, 571	2, 539, 999			Nebraska.
Nevada	229, 839	229, 124				495			220	9, 872	89, 870		130, 097		Nevada.
New Hampshire	1, 915, 291	1, 536, 502				7, 540	28, 690	264, 055	78, 504	156, 044	1, 759, 247				New Hampshire.
New Jersey	12, 963, 541	9, 293, 964	5, 680, 418	3, 613, 546	66, 552	13, 714	72, 775	2, 450, 201	1, 066, 335	532, 755	7, 900, 000	4, 530, 786			New Jersey.
New Mexico	528, 193	502, 447	444, 401	58, 046	2, 621	527	8, 759		13, 839	53, 795	316, 265	158, 133			New Mexico.
New York	31, 757, 889	28, 375, 610	20, 140, 775	8, 234, 835	76, 825	70, 654	188, 907	2, 465, 776	580, 117	1, 922, 049	22, 072, 465	4, 743, 169		[11] 3, 020, 206	New York.
North Carolina*	[12] 3, 246, 853									[13] 150, 000	[13] 2, 331, 853		[13] 765, 000		North Carolina.*
North Dakota	1, 595, 442	1, 570, 120	1, 338, 798	231, 322		1, 362			23, 960	170, 000	[14] 777, 721	647, 721			North Dakota.
Ohio	10, 745, 471	10, 398, 977				23, 014	124, 302	9, 979	189, 199	366, 883	5, 128, 532	5, 250, 056			Ohio.
Oklahoma*	5, 753, 912										2, 301, 565	3, 452, 347			Oklahoma.*
Oregon	6, 527, 341	6, 325, 637	5, 408, 300	917, 337		11, 209	29, 312	66, 636	94, 547	367, 341	1, 356, 800		[3] 4, 803, 200		Oregon.
Pennsylvania	26, 017, 495	19, 693, 780	13, 734, 183	5, 959, 597	41, 031	35, 775	330, 316	2, 325, 947	3, 590, 646	1, 565, 703	15, 048, 520	1, 501, 550	7, 800, 447	[15] 101, 275	Pennsylvania.
Rhode Island	2, 093, 309	1, 693, 999	1, 265, 199	428, 800	1, 034	4, 438	13, 440	273, 720	106, 678	179, 304	1, 914, 005				Rhode Island.
South Carolina	2, 187, 290	2, 078, 546	1, 771, 878	306, 668	22, 386	1, 293	23, 457		61, 608		2, 178, 290	9, 000			South Carolina.
South Dakota	2, 491, 981	2, 472, 926	2, 142, 266	330, 660		1, 072			17, 983	67, 463	1, 236, 999	1, 187, 519			South Dakota.
Tennessee*	3, 765, 775									92, 850	3, 672, 925				Tennessee.*
Texas	15, 626, 531	15, 045, 978	12, 583, 812	2, 462, 166	117, 998	12, 024	55, 872	69, 678	324, 981	598, 805	10, 884, 403	4, 143, 323			Texas.
Utah*	672, 403									132, 000			540, 403		Utah*.
Vermont	1, 878, 950	1, 610, 899	1, 385, 081	225, 818		4, 146	30, 350	203, 187	30, 368	119, 619	1, 759, 331				Vermont.
Virginia	5, 235, 953	4, 840, 384	4, 143, 391	696, 993	4, 692	6, 863	61, 354	39, 445	283, 215	257, 790	4, 978, 163				Virginia.
Washington	6, 482, 354	5, 930, 338	4, 606, 495	1, 323, 843	44, 869	13, 454	86, 833	399, 517	7, 343	248, 977	4, 940, 884	892, 976		[16] 399, 517	Washington.
West Virginia	4, 004, 391	3, 605, 153	3, 084, 218	520, 935	3, 396	5, 587	54, 089	136, 696	199, 470	256, 888	1, 390, 324		2, 320, 000	[16] 37, 179	West Virginia.
Wisconsin	9, 772, 887	9, 518, 220	7, 872, 419	1, 645, 801		17, 655	36, 354	103, 655	97, 003	550, 000	5, 428, 287	3, 794, 600			Wisconsin.
Wyoming	525, 807	515, 019	404, 275	110, 744		638	9, 500		650		274, 028		251, 779		Wyoming.
District of Columbia	531, 044	120, 279	99, 026	21, 253		1, 151	1, 958	185, 271	222, 385	159, 388				[17] 371, 656	District of Columbia.
Detailed totals [2]	268, 651, 211	239, 515, 394	([18])	([18])											Detailed totals.[2]
Grand total	301, 061, 132				1, 005, 315	412, 744	1, 999, 180	13, 449, 421	12, 269, 157	14, 876, 410	189, 985, 289	53, 577, 893	38, 087, 598	4, 533, 942	Grand total.

[1] All States report amounts for calendar year except North Carolina, which reports for 6 months, July 1 to Dec. 31, for registration for last half of year.
[2] The States starred do not show complete receipt details and are not included in totals under first 9 columns, shown as "Detailed total." The disposition of total gross receipts is shown for all States and such totals are shown in the last 5 columns.
[3] County bond payments in Arkansas amounted to $2,124,118; in Oregon, $1,540,000, and in Michigan the full amount shown.
[4] Undistributed receipts.
[5] Unpaid claims.
[6] To State general fund.
[7] Includes $140,000 for State police.
[8] For Baltimore city streets.
[9] Does not include part of collection expense paid from State appropriations.
[10] Includes $1,006,128 for administration of State highway department.
[11] New York City general fund.
[12] Second half of year only as fiscal year changed to agree with calendar year in 1928.
[13] Gross receipts (with motor fuel taxes) form State highway fund used for: Administration, financing highway obligations, maintenance and construction of State highway system. The data is estimated on a pro rata basis here.
[14] Includes $130,000 of special bridge fund.
[15] Refunds.
[16] Highway safety fund derived from operators' permits.
[17] For repair and construction of Washington streets, if so appropriated by Congress.
[18] Only 35 States report details of motor car registration receipts, which total here as follows: Passenger cars and busses, $167,100,356; trucks and tractors, $50,856,951; making a combined total of $217,957,307.

UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF PUBLIC ROADS

STATUS OF FEDERAL AID HIGHWAY CONSTRUCTION

AS OF

MARCH 31,1928

STATES	FISCAL YEARS 1917-1927			FISCAL YEAR 1928									BALANCE OF FEDERAL AID FUND AVAILABLE FOR NEW PROJECTS	STATES
	PROJECTS COMPLETED PRIOR TO JULY 1, 1927			PROJECTS COMPLETED SINCE JUNE 30, 1927			*PROJECTS UNDER CONSTRUCTION			PROJECTS APPROVED FOR CONSTRUCTION				
	TOTAL COST	FEDERAL AID	MILES	TOTAL COST	FEDERAL AID	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES	ESTIMATED COST	FEDERAL AID ALLOTTED	MILES		
Alabama	$ 20,061,371.68	$ 9,615,099.94	1,400.2	$ 1,504,368.28	$ 712,525.58	108.6	$ 9,869,103.11	$ 4,811,329.02	505.3	$ 448,457.56	$ 222,863.69	35.1	$ 2,082,339.77	Alabama
Arizona	11,809,950.70	6,447,189.27	800.8	624,598.32	451,055.92	15.7	1,087,792.63	827,674.26	66.1	91,051.43	58,152.85	0.5	3,949,271.70	Arizona
Arkansas	22,337,014.63	9,525,192.75	1,560.6	194,319.25	92,922.87	18.4	4,730,594.98	2,109,648.77	246.0	792,660.15	396,330.06	26.0	2,041,390.55	Arkansas
California	35,128,269.04	16,967,026.82	1,306.3	4,417,161.29	2,016,680.89	103.1	7,698,201.52	3,582,214.87	156.1	258,464.56	155,078.73	9.3	4,321,665.69	California
Colorado	15,497,121.91	7,934,298.91	829.0	865,092.55	461,241.53	53.6	6,425,353.98	3,098,699.84	235.8	373,548.50	207,336.94	18.0	3,384,155.78	Colorado
Connecticut	6,397,392.29	2,444,000.54	137.3	2,475,774.50	677,628.04	35.4	4,979,858.22	1,363,375.63	57.4	1,056,062.72	190,461.17	11.8	805,113.62	Connecticut
Delaware	6,237,026.55	2,345,572.42	159.5	646,927.21	303,850.84	34.4	762,279.37	209,908.50	11.3	209,132.53	104,566.27	8.0	241,409.97	Delaware
Florida	7,476,856.31	3,627,912.60	245.1	4,232,517.04	2,026,119.95	83.1	5,946,374.95	2,484,574.58	152.7	1,013,889.63	387,752.10	27.8	1,359,356.77	Florida
Georgia	31,951,436.50	15,101,232.40	2,173.6	6,819,785.06	3,239,437.32	236.0	4,797,661.00	2,380,582.20	200.8	1,043,454.68	485,312.12	42.3	1,184,612.96	Georgia
Idaho	13,225,515.45	7,075,527.16	835.5	1,672,690.67	1,050,478.15	114.3	2,191,398.81	1,314,265.44	151.7	545,138.29	323,950.12	16.0	663,561.13	Idaho
Illinois	48,538,982.16	22,781,516.60	1,530.8	1,894,920.13	912,725.80	67.9	15,446,195.78	7,243,789.27	498.6	6,284,544.12	3,130,922.31	207.5	2,052,898.02	Illinois
Indiana	23,372,717.74	11,238,568.20	732.5	5,296,637.76	2,471,687.84	166.7	12,374,897.93	5,958,406.82	378.2	2,853,698.89	1,403,931.83	102.3	979,995.31	Indiana
Iowa	34,306,138.86	14,395,603.75	2,484.4	6,996,585.23	3,191,018.55	393.4	8,992,222.99	3,998,183.03	223.5	3,491,634.63	1,485,053.09	14.6	495,994.58	Iowa
Kansas	37,442,061.61	14,730,829.48	1,495.2	5,480,095.37	2,386,970.38	354.7	10,783,105.20	4,249,046.52	538.5	134,207.72	52,000.00	10.2	2,176,292.62	Kansas
Kentucky	23,216,600.53	9,510,694.75	874.9	2,834,753.13	1,284,212.39	122.6	7,996,278.00	3,802,380.70	349.6	357,363.44	178,681.72	23.5	1,275,815.44	Kentucky
Louisiana	15,877,552.20	7,093,892.21	1,178.7	1,332,121.58	597,801.48	48.6	5,723,321.13	2,709,183.03	196.0	1,343,267.77	531,344.70	51.8	372,776.58	Louisiana
Maine	10,564,800.06	4,858,452.67	357.6	2,087,386.84	732,746.76	61.7	1,108,176.91	453,994.44	33.9	87,912.01	43,956.00	5.6	1,737,903.13	Maine
Maryland	11,790,203.93	5,524,938.27	477.8	1,468,140.87	684,194.40	71.2	724,190.14	357,376.05	33.4				628,573.28	Maryland
Massachusetts	20,670,246.02	7,425,928.15	410.4	773,728.83	158,264.74	9.6	7,334,334.71	2,087,701.70	130.5	78,146.64	31,500.00	2.1	2,583,239.41	Massachusetts
Michigan	31,977,248.37	14,328,484.99	1,084.2	5,967,450.00	2,652,420.04	192.9	10,729,924.21	4,712,891.31	273.1	4,554,964.10	1,807,202.00	103.6	1,265,653.66	Michigan
Minnesota	45,099,648.47	19,046,145.67	3,643.5	5,852,424.86	2,001,398.90	248.7	4,027,299.75	1,203,100.00	216.7	3,239,964.75	1,037,000.00	124.7	537,471.43	Minnesota
Mississippi	18,331,230.75	9,004,294.62	1,314.1	3,087,377.78	1,523,013.55	166.8	5,457,654.81	2,667,145.37	256.5	943,319.66	471,348.54	43.8	1,079,823.92	Mississippi
Missouri	42,389,290.41	19,681,026.48	1,944.8	4,759,322.06	2,091,099.82	169.2	6,362,830.48	2,737,541.91	206.3	1,568,314.45	670,397.18	58.9	2,415,892.61	Missouri
Montana	12,854,995.72	7,287,288.69	1,151.6	618,400.67	421,911.70	67.9	3,986,705.92	2,807,171.20	318.6	1,820,260.29	1,020,333.45	189.2	4,992,254.96	Montana
Nebraska	16,157,040.25	7,739,386.39	2,246.6	5,557,738.17	2,688,847.30	575.8	10,730,638.65	5,286,555.43	1,036.7	309,459.37	154,167.91	30.7	1,936,396.97	Nebraska
Nevada	10,421,349.31	7,589,168.88	853.6	646,706.06	553,479.11	78.1	1,743,076.97	1,524,773.83	195.8	169,673.10	146,534.92	15.8	887,763.46	Nevada
New Hampshire	5,868,897.76	2,778,928.05	264.8	848,508.33	372,238.38	27.8	780,437.14	352,772.73	22.0	181,498.06	83,607.66	1.8	313,195.18	New Hampshire
New Jersey	22,228,240.08	7,495,364.48	316.3	4,173,354.17	1,109,130.00	74.0	3,769,538.68	797,536.52	52.2	905,480.02	177,210.00	13.5	757,912.00	New Jersey
New Mexico	13,336,250.94	7,937,598.06	1,505.2	1,365,495.65	882,413.37	99.9	2,866,074.58	2,265,180.28	181.3	163,241.87	102,868.80	12.9	2,160,449.49	New Mexico
New York	54,183,085.44	21,693,955.65	1,439.3	8,270,394.76	2,710,163.93	174.7	39,107,536.00	9,370,761.45	584.3	6,486,600.00	1,325,902.50	85.9	6,209,507.47	New York
North Carolina	35,295,849.21	14,518,903.16	1,460.1	3,072,681.24	1,431,904.59	112.9	1,870,962.46	882,448.18	43.1	1,679,658.00	824,764.14	64.4	1,488,451.93	North Carolina
North Dakota	15,881,558.55	7,746,293.68	2,715.6	3,729,368.44	2,054,168.62	488.9	3,505,711.40	1,731,661.61	551.5	1,176,967.61	516,945.47	171.6	1,087,980.62	North Dakota
Ohio	52,621,391.49	19,331,376.76	1,515.0	6,914,056.19	2,908,029.57	231.9	7,863,330.64	2,989,049.92	185.5	5,035,607.20	1,942,336.26	124.8	4,081,176.49	Ohio
Oklahoma	30,381,957.08	14,117,589.21	1,268.1	1,385,066.33	617,029.12	57.6	6,685,912.08	3,003,684.98	388.1	731,835.42	357,640.14	27.5	1,464,800.55	Oklahoma
Oregon	19,583,584.76	10,041,452.94	1,055.0	591,912.35	325,162.75	16.5	2,550,851.18	1,327,846.88	71.2	455,302.65	242,118.11	8.2	1,314,675.32	Oregon
Pennsylvania	77,726,174.22	26,317,220.32	1,534.3	7,360,151.05	2,253,430.31	153.1	14,791,021.30	4,526,930.97	276.2	7,036,164.38	2,096,799.98	133.5	2,813,520.42	Pennsylvania
Rhode Island	5,233,413.38	1,998,479.06	116.0	700,482.52	227,205.00	15.1	1,446,803.79	389,422.41	24.2	569,048.13	138,825.00	9.2	644,887.53	Rhode Island
South Carolina	17,002,039.93	7,526,988.80	1,568.4	2,521,297.49	1,198,355.38	70.7	9,674,988.58	2,659,986.16	263.1	2,224,496.47	377,000.00	36.4	153,714.66	South Carolina
South Dakota	19,262,063.24	9,507,525.54	2,502.9	1,249,757.94	678,550.24	232.0	4,272,577.06	2,258,582.25	629.6	501,866.08	265,882.37	95.5	900,294.60	South Dakota
Tennessee	24,283,035.03	11,551,457.55	868.7	3,549,497.62	1,590,594.64	96.3	7,460,398.22	3,128,728.14	210.8	3,814,138.67	1,404,251.65	36.1	832,337.02	Tennessee
Texas	78,190,246.37	31,566,960.45	5,486.4	9,235,029.21	4,227,105.34	355.8	14,551,547.16	6,168,325.15	431.3	3,610,194.77	1,455,687.46	137.5	6,188,200.60	Texas
Utah	9,154,377.33	5,767,079.95	628.9	1,519,607.25	1,122,910.11	128.8	2,427,042.97	1,677,878.04	133.9	444,885.71	344,705.72	33.1	601,204.18	Utah
Vermont	5,037,118.23	2,348,866.01	152.7	2,058,524.16	804,449.43	42.8	1,271,358.62	446,721.78	28.8	213,383.29	48,140.00	4.4	351,589.78	Vermont
Virginia	26,844,025.24	12,537,143.25	1,168.9	1,904,466.28	824,401.18	51.7	3,801,229.62	1,531,148.07	77.7	3,428,027.16	842,658.64	89.4	646,424.86	Virginia
Washington	18,184,505.97	8,246,551.95	711.1	2,976,519.51	1,306,714.32	62.1	2,644,260.16	1,134,600.00	83.6	2,555,139.78	784,000.00	49.4	948,667.73	Washington
West Virginia	10,424,847.32	4,573,748.01	419.4	3,998,929.96	1,561,360.55	110.6	4,432,608.90	1,969,333.43	176.2	164,340.61	67,899.94	4.4	767,601.07	West Virginia
Wisconsin	27,891,502.16	11,847,858.90	1,729.5	7,124,245.54	3,373,834.65	274.0	5,125,553.80	2,231,821.76	190.9	1,214,073.39	577,000.00	44.9	3,142,966.69	Wisconsin
Wyoming	12,650,712.15	7,139,267.05	1,315.9	1,655,408.97	1,051,830.11	102.8	2,058,725.51	1,322,970.11	217.4	82,443.28	52,928.57		873,194.16	Wyoming
Hawaii	343,664.15	97,440.00	6.5	866,148.12	275,109.33	14.1	1,217,433.12	337,110.89	18.9				1,121,742.78	Hawaii
TOTALS	1,154,740,601.48	510,007,691.24	60,957.6	155,177,916.59	68,289,824.77	6,592.5	306,185,374.92	126,486,015.43	11,510.8	75,742,973.54	28,725,350.11	2,363.5	84,115,118.45	TOTALS

* Includes projects reported completed (final vouchers not yet paid) totaling: Estimated cost $ 87,211,295.12 Federal aid $ 36,351,738.01 Miles 3,178.9